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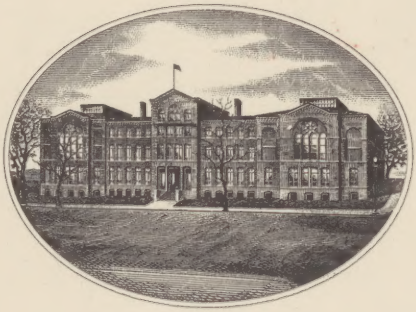

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U. S. Department of Health, Education, and Welfare

Public Health Service

PRINCIPLES

OF

GENERAL PHARMACY

WITH SPECIAL REFERENCE TO

SYSTEMS OF WEIGHTS AND MEASURES,

SPECIFIC GRAVITY AND ITS USES,

PHARMACEUTICAL MANIPULATIONS.

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PREFACE.

THE design of these "Lectures" is to present to the student of Pharmacy a course of instruction on Weights and Measures, Specific Gravity and its uses, and all operations occuring in pharmaceutical practice, in the most simple manner possible. These lectures are based upon a course adopted by the late Professor A. Fennel when occupying the chair of Pharmacy in the Cincinnati College of Pharmacy. Each topic will be considered thoroughly in consise terms, and be in as condensed a form as practicable. In conclusion, the compiler ventures to express the hope that the work will meet with kind consideration, and prove serviceable to the pharmaceutical student.

CINCINNATI, June, 1886.

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INTRODUCTORY.

PRESCRIPTIONS.

The art of prescribing medicines is so closely connected with that of preparing and dispensing them, that it seems proper to devote a few lines to the subject. The greatest difficulty is experienced by recent graduates of medicine to write a prescription correctly; simply because they lack systematic instruction and more frequently are wanting in the Latin language. It is surprising that so little attention is paid to such an important branch of knowledge by our Medical Colleges. Although the art of prescribing can only be acquired practically, the general principles pertaining to it should be thoroughly understood by the practical pharmacist.

Prescription. The word prescription is derived from the Latin word *Præscriptio*, a derivative of *Præscribo*, signifying "before I write." The word may therefore be defined as the art of directing remedies for a disease and the manner of using them, or a formula for making some combination of materials for medicine. In writing prescriptions, the Latin language should be used, since it is the predominant one in all countries excepting France, where the vernacular is employed.

Advantages. The advantages derived by the use of the Latin language are obvious: 1st, it is a dead language and therefore not subject to any changes; 2nd, it insures accuracy without any unnecessary or cumbersome phraseology. For instance, should the physician prescribe snake root, the pharmacist would be at a loss to know what to take and be perfectly justified in taking either the Black, White, Senega, Canada or Virginia snake root, and many others locally known as snake root; but if the Latin terms are used, as *Cimicifuga Racemosa*, (*Sanicula Marilandica*, also known as black snake root) *Eupatorium Aromaticum*, *Polygala Senega*, *Asarum Canadense*, *Serpentaria Virginiana*, respectively, there can be no doubt.

Likewise Chamomile; in this instance it would be necessary to state what kind, Roman or English, or German; while the Latin *Anthemis*, *Matricaria*, both short and distinct, give the most explicit information.

Frequently, Hemlock is ordered and the use of such an indefinite term might cause serious consequences, while the Latin *Conium Maculatum*, *Abies Canadense* will avoid all occasion for error.

Such terms, as Hellebore, Poke Root, Mustard and Oak Bark are frequently used; these are very indefinite and liable also to produce very serious results.

The importance of employing the officinal Latin titles rather than the English or vernacular titles, even when long custom has sanctioned their use, can not be overrated. This is clearly demonstrated by the use of the words "Hellebore" and "Poke root." Hellebore might be intended for the Black, Green, American and White Hellebore. *Helleborus Niger* and *Helleborus Viridis*, although at present little employed, are considered comparatively safe drugs, while *Veratrum Viride* and *Veratrum Album* are highly active and to be employed with caution. The American Hellebore, (*Veratrum Viride*) is known also by the name of Poke root, and might therefore be taken for *Radix Phytolaccæ*.

Of frequent occurrence are such terms as Sugar of Lead, White Vitriol, Liver of Sulphur, Blue Stone, etc. These express nothing, while the Latin terms give the chemical composition in short and explicit words capable of correct abbreviation.

Thus, *Plumbi Acetas*, signifies Acetate of Lead; *Zinci Sulphas*, Sulphate of Zinc; *Potassa Sulphurata*, Sulphuret of Potassium; *Cupri Sulphas*, Sulphate of Copper; giving their true composition in scientific language.

The Latin terms are nearly alike in all countries and therefore offer another reason for their adoption in writing prescriptions. Frequently the physician desires to keep his patient in ignorance of what is prescribed, which at the present day, with such an enlightened public, is a very difficult matter; on such an occasion, obsolete Latin terms are used. For example, *Aquila alba* for *Hydrargyri Chloridum Mite*, *Lapis divinus* for *Cuprum aluminatum*, *Lapis infernalis* for *Argenti nitras fusus*, *Kali oxymuriaticum* for *Potassii chloras*, *Tartarus depuratus* for *Potassii bitartras*.

It is often urged that the Latin used is incorrect, especially, when terminations are attempted; these grammatical errors may be overlooked, but not chemical or pharmaceutical ones when produced by improper abbreviation.

Prescriptions should be written plainly and carefully, without any unnecessary flourishes, thereby often avoiding mistakes. The name of each ingredient and quantity should occupy but one line, and if abbreviated, should be done properly; that is, avoiding ambiguous terms.

The symbols used to designate the weight should be plainly and carefully drawn. The Roman numerals being used to designate quantities, written after the ingredients, care being taken to dot the i's to avoid any possibility of errors.

Parts of a Prescription. The parts of a prescription may be classified under six heads, which are essential and should be of importance to the pharmacist.

1st. The name of the patient should head the prescription, since it will be a safeguard both for the patient and nurse, and furthermore will enable the druggist to consider the correctness of the prescribed dose.

2nd. The symbol ℞, an abbreviation of the word *Recipe*, "take," the imperative of the Latin verb *Recipio*. The French use the letter "P," for the word *Prenez*, from the verb *Prendre*. The symbol ℞ is really a modification of the symbol ♃, which was the heathen invocation to Jupiter, imploring his blessing. This part is known as the "Superscription."

3rd. The medicinal ingredients and quantities is called the "Inscription." This part of the prescription is the most important, although the order of writing these seems to be of little importance to the physician; but a competent pharmacist must know how and in what order to take the medicinal parts to fill the prescription properly. It is important that he considers the nature of each ingredient prescribed and the effect produced by their action upon each other and thereby be governed in the preparing of the prescription. The inscription may consist of four parts, namely: 1st, the basis or chief active ingredient; 2nd, the adjuvant, a substance added to aid the operation of the basis; 3rd, the corrective, substance added to qualify the action of both; 4th, the diluent, the substance giving the product consistence or form.

Symbols of weight and measure as used in prescriptions are as follows:

Gr.	*Granum vel grana*,	A grain or grains.
℈.	*Scrupulus vel scrupuli*,	A scruple or scruples.
ʒ.	*Drachma vel drachmæ*,	A drachm or drachms.
℥.	*Uncia vel unciæ*,	An ounce or ounces.
lb.	*Libra vel libræ*,	A pound or pounds.
m.	*Minimum vel minima*,	A minim or minims.
f ʒ.	*Fluidrachma vel fluidrachmæ*,	A fluidrachm or fluidrachms.
f ℥.	*Fluiduncia vel fluiduncia*,	A fluidounce or fluidounces.
O.	*Octarius vel octarii*,	A pint or pints.

Whenever the quantities prescribed exceed the maximum dose allowed by the U. S. Dispensatory, (the authority of the pharmacist), it should be his duty for self-protection to call on the physician and

insist on underlining or placing an exclamation point behind such quantity, thereby acknowledging the excessive dose.

4th. This part has reference to the manner of mixing and dividing the medicine and is called the "Subscription." This part generally consists of abbreviations or letters with which the pharmacist should be familiar, although he may not know the exact Latin for the terms employed, such as "M. ft.", meaning *misce fiat*, mix and make, M. D. S., for *Misce da Signa*, meaning Mix, Give and Sign, D. T. D., for *Dentur tales doses*, meaning, give such doses. Ft. pulv., for *fiat pulvis*, meaning, make a powder, and thus many more, which may be found in the latter part of the U. S. Disp., and with which the student should become familiar.

5th. The directions for taking the medicine are intended for the patient. The directions should always be given in full, and if there be any doubt in regard to the dose, it would be well for the pharmacist to consult the physician to protect himself against any errors. This part of the prescription is known as the *signatura*.

6th. The physician's name should always appear in full as an acknowledgment to his responsibility.

The following prescription will illustrate the foregoing parts:

1. .....For Mr. Jones.
2. R..... .....(Superscription.)
3. (Basis) *Atropinæ Sulphatis*.....gr $\frac{1}{120}$
   (Adjuvant) *Morphinæ Sulphatis*....: gr $\frac{1}{4}$
   (Corrective) *Syrupi Aurantii*..... f℥ss
   (Diluent) *Aquæ q. s. ft*.....f℥i
   .....(Inscription.)
4. *Mft*..... ..(Subscription.)
5. *Signa*—Teaspoonful every night on retiring .....(*Signatura*.)
6. Dr. A. B. Smith.

The Metric System in Prescriptions. The adoption of the Metric System by the Pharmacopœia of 1880, and its general introduction by the medical profession in prescription writing, has made it necessary for every pharmacist to be thoroughly acquainted with the methods employed in writing such prescriptions. The principles upon which the system is based are explained in the Second Lecture. Two distinct methods are employed in this country, known respectively, the Gravimetric and the Volumetric Method.

Gravimetric Method. In this plan, which is almost exclusively used in Europe, no *measures* of capacity are employed; that is, liquids are weighed instead of being measured. The unit of weight

being the Gramme. This method has as yet not found many supporters in this country, simply because the old custom of measuring liquids is so much more convenient.

VOLUMETRIC METHOD. In this plan, all solids are weighed, and all liquids are measured; the unit of weight being the gramme, the unit of measure, the cubic centimeter. It is not in the province of the writer to discuss the advantage or disadvantage of either system in a book of this kind; suffice it, that every druggist should be prepared to fill promptly any prescription written according to the metric system by having a set of metric weights and measures.

The following prescriptions illustrate the method of using the Metric System.

GRAVIMETRIC METHOD.

℞

Pulv. Rhei.....	13.00
Pulv. Aloes.....	9.75
Pulv. Myrrhæ...	6.50
Ol. Menth. pip...	0.65

Mft. pilulæ No. 100

This form, generally used according to the principles of the Metric System, is the only correct method.

℞

Pulv. Rhei.....	13|00
Pulv. Aloes.....	9|75
Pulv. Myrrhæ...	6|50
Ol. Menth. pip...	|65

Mft. pil. No. 100

This form is sometimes used to avoid any errors that may be occasioned by the use of the period.

℞

Pulv. Rhei.....	13. Gm.
Pulv. Aloes.....	9.75 Gm.
Pulv. Myrrhæ.....	6.5 Gm.
Ol. Menth. pip.....	.65 Gm.

Mft. pil. No. 100

This form is also used, but the abbreviation Gm is superfluous, since the period indicates Metric System, and it may also be mistaken for abbreviation of grain.

VOLUMETRIC METHOD.

Gramme and Cubic Centimeter.

℞

Sodii Salicylatis.....	8.00 or 8	.....or .8 Gm.
Syr. Anranti.....	30.00 or 30	.....or 30 C. c.
Aquæ Distillatæ.....	90.00 or 90	.....or 90 C. c.

Mft. Mxt.

APPROXIMATE MEASUREMENT.

In administering medicines, we make use of certain household implements for measuring. These, although not precise nor uniform, are sufficiently accurate for ordinary purposes. Custom has affixed certain values of capacity to these which are considered as follows:

A teacup is estimated to contain about four fluidounces, or a gill.
A wineglass.....two fluidounces.
A tablespoonful.....half a fluidounce.
A teaspoonful.....a fluidrachm.

In conclusion, the prescription should be received with dignity by the pharmacist, and all questions answered cheerfully, being careful not to say anything that might impair confidence. The pharmacist should never discuss with the patient the possible therapeutical effects, nor express his opinion as to the disease indicated by the ingredients prescribed. He should at all times sustain the physician and co-operate with him, productive of a spirit of mutual respect between both professions, and protect each other from unjust censure.

The prescription should be read carefully, each ingredient checked as used, and read again when the preparation is completed. Any alteration or addition that the pharmacist may be justified in making, must be noted on the prescription, so that a repetition of the prescription will not vary from the original. The prescription should be numbered and dated, and the corresponding number placed on the label. The directions, the name of patient and physician should be written plainly and the prescription filed away for future reference.

PRINCIPLES OF GENERAL PHARMACY.

LECTURE I

WEIGHT AND MEASURE.

Among the operations performed in dispensing medicines, none is of more frequent occurence than that of weighing and measuring.

The instruments used are the balance or scale and the measure or graduate.

The balance consists of a lever or beam supported at its center of gravity in such manner as to give it the greatest practicable freedom of motion.

The lever is generally supported on knife edges, and according to the sharpness of these, and the hardness of the planes on which these rest, depends the delicacy of indication.

The weight of a body is the measure of its gravitating force, and this is in direct proportion to the quantity of matter it contains.

We have various kinds of force in nature, the most prominent being the force of gravitation. It is in virtue of this force that a body falls to the ground, and it is in virtue of this same force that our earth moves around the sun. Thus weight is a term applied to the measure of a force known as gravity; therefore the latter is the cause, while the former is the effect produced.

This force "weight" is expressed with relation to some known and recognized standard of resistance, which is just sufficient to keep the lever or beam horizontal.

The standards thus used to express weight, are however arbitrary, and frequently differ in different countries, and often different standards are used in the same country. It is to be regretted that not one uniform system can be used throughout all countries. In this country four systems are used, viz: the Apothecary System, used in preparing medicines and medicinal compounds. The Troy System, used only by jewelers. The Avoirdupois System, for buying or selling drugs, and used by all other class of merchants. The Metric System, generally in works of science, and now frequently used by physicians. In France and Germany it is now the only system of weight used.

The origin of measures of length is to be found in parts of the human body, (the foot, diget, palm, nail, arm), and are in all languages derived from the same source.

Thus natural products, such as seeds, formed the basis of the first system of weights.

According to a law enacted in the year 1266, in England, "An English penny weighed thirty-two wheat corns, taken from the midst of the ear; twenty such pence make an ounce, and twelve ounces one pound."

In the year 1304, according to another law, states "that every pound of money or of medicines is of twenty shillings weight, but the pound of all other things is twenty-five shillings weight. The ounce of medicine consists of twenty pence and the pound contains twelve ounces, but in other things the pound contains fifteen ounces, in both cases the ounce weighing twenty pence."

In the year 1816 England introduced a standard on a basis easily recoverable in case of loss or destruction. In 1799 the system originating with Prince De Talleyrand, known as the Metric System, was introduced. This system

meeting with popular favor, induced England to originate the system, adopted in 1816.

To obtain this greater degree of uniformity and certainty, the length of a pendulum vibrating seconds of mean time, in a vacuum at a temp. of 62° F. at the level of the sea, was obtained, which was found to be nearly one meter, the cube of this: measure of capacity; filled with distilled water at a temp. of 62° F. and the barometer standing at 30 inches formed a basis of weight.

The units of length and weight in use in this country are by no means well adapted for the purpose of science, in which respect the metrical system of France has decided advantages over all others. Being a decimal system, all calculations are by it rendered extremely simple, and furthermore it is in general use among all scientific men.

In the Metric System, the unit from which all other calculations are made, is also one of extension. Instead of taking the length of pendulum oscillating in a certain period of time, the unit of length was determined from the measurement of a meridian of the earth. Thus, the ten millionth part of a quadranth, that is the quarter of the earth's meridian, formed the unit of length and was called the meter.

The meter was divided into tenths, hundredths, thousandths, etc., and multiples of tens; using the Latin prefix for the divisions and the Greek prefix for the multiples. The cube of $\frac{1}{10}$ meter or decimeter formed the measure of capacity and was called the Liter. The cube of $\frac{1}{100}$ meter or centimeter was called the cubic centimeter or mille liter.

The weight of water at its greatest density, 4° C, contained in this cube, was called a gramme.

Table of the Different Systems of Weight.

APOTHECARIES' WEIGHT. U. S.

Pound.		Troy Ounces.		Drachms.		Scruples.		Troy Grains.
℔ 1 lb.	=	12	=	96	=	288	=	5760.
		℥1	=	8	=	24	=	480.
				ʒ1	=	℈ 3	=	60.
						℈1	=	20.

TROY WEIGHT.

This system corresponds with the Apothecary System in pounds, ounces and grains, but differs from it in the division of the ounce, containing (20) twenty pennyweights, each of 24 grains.

AVOIRDUPOIS WEIGHT. BR.

Pound.		Ounces.		Drachms.		Troy Grains.
℔ 1 lb.	=	16	=	256	=	7000.
		oz. 1	=	16	=	437.5
				dr. 1	=	27.34375

METRIC SYSTEM OF WEIGHT.

Milligramme	=	mg.	=	$\frac{1}{1000}$	= .015432 Troy Grains.
Centigramme	=	cg.	=	$\frac{1}{100}$	= .15432 "
Decigramme	=	dg.	=	$\frac{1}{10}$	= 1.5432 "
Gramme	=	Gm.	=	1	= 15.43234874 "
Decagramme	=	Dg.	=	10	=154.32348 "
Hectogramme	=	Hg.	=	100	=1543.2348 "
Kilogramme	=	Kg.	=	1000	=15432.348 "
Myriagramme	=	Mg.	=	10000	=154323.487 "

The Gramme may be considered as 15.5 Troy Grains, but nearer accurate 15.434 Troy Grains.

Examples illustrating how to obtain the relative value of the various systems of weight.

Ex. 1. To reduce 1 lb. ℥ 2, ℥ 6, ℈ 2, (Apoth.) to Avoirdupois and the Metric System.

1lb. = 5760 Troy Grains.
℥2 = 960 " "
℥6 = 360 " "
℈2 = 40 " "

7120 " "

Since the Avoirdupois pound contains 7000 Troy grains, this will form the first divisor for the reduction to Avoir. System.

7000) 7120 (1 lb.
7000

120 grs.

27.343) 120.000 (4 dr.
109.372

10.628 Troy grains remainder.

The next divisor will be 27.343 +, being the number of Troy grains in the Avoirdupois drachms.

Answer: 1 lb. 4 dr. 10.628+ grs. Avoir.

To reduce to the Metric System divide the total number of Troy grains by 15.434; the number of Troy grains equivalent to 1 gramme.

15.434) 7120.000000 (461.312+ Grammes.
6173 6

94640
92604

20360
15434

49260
46302

29580
15434

41460
30868

10592

Answer: 4 Hg., 6 Dg., 1 Gm., 3 dg., 1 cg., 2 mg.

Ex. 2. To reduce 1 Kilogramme to Avoir. and Apoth. System.

1 Kilogramme = 1000 gramme.
1 Gramme = 15.434 Troy grains.
1 Kg. = 1000×15.434 = 15434.000 grains Troy.

5760) 15434.000 (2 lbs.
11520

480) 3914 (8 ℥.
3840

60) 74 (1 ʒ.
60

14

Since the Apothecary pound contains 5760 Troy grains, this will form the first divisor for the reduction to Apothecary System.

For like reason 480 and 60 form the next divisors.

Answer: 2 lbs., ℥8, ʒ1, 14 grs. Apothecary Weight.

7000) 15434 (2 lbs.
14000

Since the Avoirdupois pound contains 7000 Troy grains, this will form the first divisor for the reduction to the Avoirdupois System.

437.5) 1434.0000 (3.277 ounces.
1312 5

12150
8750

34000
30625

33750
30625

3125

The next divisor is 437.5 since the Avoir. ounce contains that number of Troy grains. For the sake of convenience and to avoid fractions as much as possible, the division is continued to *parts* of an ounce.

.277 ounces.
16

1662
277

4.432 dr.

The fractional part of an ounce is reduced to drachms by *multiplying* by 16, since there are that number of drachms to the Avoirdupois ounce.

.432 drachms.
27.343

1296
1728
1296
3024
864

11.812176 grs.

The fractional part of a drachm is reduced to Troy grains by *multiplying* by 27.343, the number of Troy grains to the Avoirdupois drachm.

Answer: 2 lbs., 3 oz., 4 dr., 11.81+ grains.

Ex. 3. To reduce 2 lbs., 5 ounces, 6 drachms, Avoirdupois Weight to the Apothecary and Metric System.

2 lbs. = 2×7000 = 14000 Troy grains.
5 ozs. = 5×437.5 = 2187.5 "
6 drs. = 6×27.343 = 164.058 "

16351.558 grains.

To Apothecary System.

5760) 16351.558 (2 lbs.
11520

480) 4831 (10 ℥.
4800

20) 31 (1 ℈.
20

11.558 grs.

Answer: 2 lbs., ℥x., ℈i., 11.558 grains, Apothecary Weight.

To Metric System.

15.434) 16351.55800 (1059.45+ Grammes.
15434

91755
77170

145858
138906

69520
61736

77840
77170

1000 Grammes to Kilogramme, therefore 1059.45 + Grammes = 1 Kilogramme, 5 Dg., 9 Gm., 4 dg., 5 cg.

Ex. 4. Reduce 2 lbs., ℥2., ʒ3, ℈2 Apothecary Weight to Avoirdupois and Metric Weight.

Ex. 5. Reduce 1 lb., 3 ounces, 7 drachms Avoirdupois to Apothecary and Metric Weight.

Ex. 6. Reduce 2 Kilo., 5 Hecto., 7 Decagrammes to Avoirdupois and Apothecary system.

Table of the Different Systems of Measure.

APOTHECARIES' OR WINE MEASURE. U. S.

Gallon.		Pints.		Fluidounces.		Fluidrachms.		Minims.
1	=	8	=	128	=	1024	=	61440
		O 1	=	16	=	128	=	7680
				f. ℥ 1	=	8	=	480
						f. ʒ 1	=	60

IMPERIAL MEASURE. BR.

Gallon.		Pints.		Fluidounces.		Fluidrachms.		Minims.
1	=	8	=	160	=	1280	=	76800
		O 1	=	20	=	160	=	9600
				f. ℥ 1	=	8	=	480
						f. ʒ 1	=	60

METRIC MEASURE.

Milliliter	=	$\frac{1}{1000}$	=	Cc.
Centiliter	=	$\frac{1}{100}$	=	cl.
Deciliter	=	$\frac{1}{10}$	=	dl.
Liter	=	1	=	l.
Decaliter	=	10	=	Dl.
Hectoliter	=	100	=	Hl.
Kiloliter	=	1000	=	Kl.
Myrialiter	=	10000	=	Ml.

WEIGHTS OF CERTAIN MEASURES OF DISTILLED WATER AT 62° FAHR.

One fluid ounce Imperial Measure weighs 437.5 grs. or fluid grains.
One fluid ounce Wine Measure weighs 455.69 grs. or fluid grains.
One Milliliter or C.c., weighs 15.434 grs. or fluid grains.

Therefore the Imp. fld. ounce corresponds to the Avoirdupois ounce, and Cubic Centimeter corresponds to the Gramme, and for the sake of convenience 1 fluid grain corresponds to 1 grain.

Examples illustrating how to obtain the relative value of the different systems of measure.

Ex. 1. Reduce 1 pt., 5 f. ℥., Wine Measure to Imperial and Metric Measure.

1 Pt. = 16 fld. ℥.
5 fld. ℥. = 5 fld ℥.

21 fld. ℥.
455.69 fluid grains to the fluid ounce Wine Measure.

189
126
105
105
84

437.5) 9569.4900 (21.873+ fluid ounces Imp. Measure.
8750

8194
4375

38199
35000

31990
30625

13650
13125

525

Since 437.5 fld. grs. are contained in the Imperial fluid ounce, this forms the first divisor.

20) 21 Imp. Measure.
1 pt. 1 ℥.

Since there are 20 fld. oz. to the Imperial pint, this forms the divisor for the reduction to pints.

.873 fld. ℥.
8
6.984 fld. ℥.
60
59.040 Minims.

The fractional part of a fluid ounce is reduced to fluid drachms by multiplying by 8, the number of fluid drachms to the fluid ounce. The fractional part of a fluid drachm is reduced to minims by multiplying by 60, the number of minims in the fluid drachm, Imperial and Wine Measure.

Ans. 1 pt. 1 f. ℥. 6 f. ℥., 59+ minims, Imp. Measure.

To Reduce to Metric Measure.

Since 15.434 fld. grs. are contained in the cubic centimeter.

15.434) 9569.49000000 (620 + C. C.
9260 4
3090 9
3086 8
41

Ans: 6 dl., 2 cl.,+ or 620+ C. C.

Ex. 2. Reduce 2 gal. 6 pts. Imp. to Wine and Metric Measure.

2 Gal. = 16 Pts.
6 Pts. = 6 Pts.
22 Pts. = 22×20 = 440 fld. oz.

The fluid ounces are reduced to fluid grains by multiplying by 437.5; since there are 437.5 fluid grains to the fluid oz. Imperial Measure.

437.5
2200
3080
1320
1760
192500.0 fld. grs.

455.69) 192500.000000 (422.4363 + fld. oz.
182276
102240
91138
111020
91138
198820
182276
165440
136707
287330
273414
139160
136707
2453

Since the fluid oz., Wine Measure contains 455.69 fluid grains, this forms the first divisor for the reduction to fluid ounces, Wine Measure.

16) 422 fld. oz. (26 pts. 6 fld. oz.
32
102
96
6

Fluid ounces reduced to pints by dividing by 16, since there are that number of fluid ounces to the pint, Wine Measure.

26 pts. = 3 gal. 2 pts.

The fractional part of a fluid ounce is reduced to fluid drachms by multiplying by 8, the number of fluid drachms to the fluid ounce. The fractional part of a fluid drachm is reduced to minims by multiplying by 60, the number of minims in the fluid drachm, Imperial and Wine Measure.

.4363 fld. oz. = 3 fld. dr. +
8
3.4904 fld. dr. Wine Measure.
60
29.424 Minims.

Ans: 3 gal., 2 pts., 6 fld. ℥., 3 fld. ʒ., 29. Mins. Wine Measure.

15.434) 192500.000000 (12472.463+ C. C.
15434
38160
30868
72920
61736
11180
108038
38020
30868
71520
61736
97840
92604
52360

Since 15.434 fluid grains are contained in the cubic centimeter, this number will form the first divisor for the reduction to cubic centimeters.

$\frac{12472}{1000}$ = 12. Liter + 472 C. C.

Answer: 12 Liter, 472.463 C. C.

Ex. 3. Reduce 5 Liter, 75 C. C. to Wine and Imp. Measure.

5 Liter = 5000 C. C.
75 C. C. = 75 C. C.

5075 C. C.
15.434

20300
15225
20300
25375
5075

455.69) 78327.55000 fld. grs. (171.887+ fld. oz.
45569

327585
318983

86025
45569

404560
364552

400080
364552

355280
318983

36297

171 fld. oz. = 1 gal., 2 pts., 11 fld. ℥.
.887 fld. oz. 7 fld. ʒ, 5.76+ minims, Wine Measure.

Reduction to Imperial Measure.

437.5) 78327.5500 (179.856 fld. oz.
3375

34577
30625

39525
39375

1505

179 fld. oz. = 1 gal., 19 fld. oz.
.856 fld. oz. = 6 fld. dr., 50.8+ minims, Imperial Measure.

Answer: 5 Liter, 75 C. C. correspond to 1 gal., 2 pts., 11 fld. ℥, 7 fld. ʒ, 5.76+ minims Wine Measure, or 1 gal., 19 fld. ℥, 6 fld. ʒ, 50.8+ minims Imperial Measure.

In all the preceding calculations on the subject of *measures*, it must be borne in mind that the basis is Distilled Water at 62° Fahr. The student, to be thoroughly conversant with the different systems of weights and measures, should apply himself to the solution of the following problems. The importance of the subject will be apparent, especially when specific gravities are considered. In the following Lectures the subject will be thoroughly discussed, especially in reference to absolute weight and specific volume.

Ex. 4. Reduce 1 gal., 6 fld. ℥, Wine Measure to Imperial and Metric Measure.

Ex. 5. Reduce 2 gal., 3 pts., 10 fld. ℥, Imperial Measure to Wine and Metric Measure.

Ex. 6. Reduce 1 Liter to Wine and Imperial Measure.

LECTURE II.

SPECIFIC GRAVITY.

Archimedes furnished the first means for ascertaining the relative density of bodies.

Supposing that in the midst of a vessel of water a portion should become rigid, however, retaining its density, its volume and all other properties, it will still retain its position in the center of the fluid. By its own weight according to the laws of gravity, it will be drawn downward, but since it remains in its original position, this force must be counteracted by an equal, but opposite force, due to the pressure of the water in which it is immersed. Thus it appears that the buoyancy or floating power of a fluid is sufficient to counteract the weight of a solid immersed in it, provided it is of the same density as the fluid itself. If, however, a solid immersed in a fluid be of a greater density than the fluid, the upward pressure will not be sufficient to overcome the weight of the solid, but it will appear to lessen it by the weight of its own volume of the fluid in which it rests. If the solid is left to itself it will sink, but if supported by a thread, it will act as a heavy body, but not with a force due to its whole weight, but with the same force less the weight of its bulk of the fluid in which it is immersed. If however, the solid be lighter than the fluid it will not sink therein, but a certain portion of its volume will become immersed to such an extent that the weight of the bulk of the fluid equal to the immersed portion will be equal to the whole weight of the solid. By taking advantage of these properties we are enabled to ascertain the relative density of bodies.

The standard adopted, is distilled water at a temperature when it has its maximum density (4° C.), 760 M. M. pressure. This standard is considered unity or one, and forms the basis for estimating the density of solids and liquids. The temperature specified in the U. S. Pharmacopœia, is 60° F. (15.6° C.)

The standard for gases and vapors—the atmosphere. Hence Specific Gravity or Weight is the re'ative weight of a body compared with the weight of an equal volume of water or air.

Three methods are usually employed in determining the specific gravities of solids and liquids. These are—the method of the hydrostatic balance; that of the hydrometer and that of the specific gravity flask. All, however, depend on the same principle, that is, first ascertaining the weight of the body, and then the weight of an equal volume of water.

HYDROSTATIC BALANCE.

The hydrostatic balance is nothing more than an accurate balance so arranged that one of the pans is suspended with shorter strings, and to the bottom of the pan is attached a hook. To determine the Sp. Gr. of a solid substance insoluble in water, the following process is adopted. The substance is first weighed in the usual manner, the weight is carefully noted as the weight of the substance in air. The substance is then attached to a fine thread or horse hair and fixed to the hook beneath the pan; thus suspended, the substance is weighed, immersed in water, and the weight again noted.

The object in weighing the substance in water is to ascertain the weight of a volume of water equal to that of the substance immersed, founded on the facts previously illustrated. This latter weight will show a decrease

of the weight in the air, and the difference between the two weights is the weight of the volume of water displaced, or the weight of a volume of water equal to that of the substances weighed.

Having obtained the weight in air and the weight in water, determine the difference in weights; this will be the weight of the volume of water displaced; this volume being equal to the volume, bulk or space occupied by the solid in air. Since Specific Gravity is only a comparison of the weights of equal bulks compared with water; dividing the weight in air by the weight of the equal bulk of water, would give the Specific Gravity of the solid. Thus, the following will illustrate the principle.

Examples illustrating how to determine the specific gravity of a body.

1st. *Solid insoluble in water, but heavier than water.*

Ex. 1. A nail weighs in air 50 grs., in water 43 grs., what is its specific gravity?

Nail weighs in air.....50 grs.
Nail weighs in water.....43 grs.

Loss..... 7 grs.

therefore, the loss 7 grs. must be equal to the weight of the bulk of water displaced by the nail, according to the principles and facts established; and, since specific gravity is only the relative weight compared with an equal volume of water, therefore $\frac{50}{7} = 7.14$ will give the specific gravity of the nail.

2nd. *Solid insoluble in water, but lighter than water.*

Ex. 2. A piece of wax weighs in air 120 grs. The wax and same nail suspended in water 38 grs., what is the specific gravity of the wax?

Wax in air.....120 grs.
Wax and nail in air.....170 grs.
Wax and nail in water ..... 38 grs.
Weight of water displaced..... 132 grs.
Weight of water displaced by nail..... 7 grs.
Weight of water displaced by wax..... 125 grs.

therefore $\frac{120}{125} = 0.96$, specific gravity of the wax.

Ex. 2. The same as follows:

Wax weighs in air.....120 grs.
Nail weighs in water..... 43 grs.
Wax and nail in water weighs ..... 38 grs.

therefore 5 grs *more* loss is occasioned; if the wax had been placed on the water without the nail attached, it would have displaced a volume of water, the weight of which would have been 120 grs.; but by being attached to the nail, it was wholly immersed; and therefore, the bulk of water displaced would weigh 5 grs. more than the wax, or in all 125 grs.; consequently specific gravity of the wax is $\frac{120}{125} = 0.96$.

3rd. *Solid soluble in water, but lighter than water.*

Ex. 3. A piece of Potassium weighs in air 64 grs., in Petroleum of the specific gravity 0.75, it weighs 8.5 grains, what is the specific gravity of the Potassium?

Weight in air..... 64 grains.
Weight in Petroleum..... 8.5 grains.
The loss or weight of the volume of Petroleum displaced is..... 55.5 grains.

The specific gravity of the Petroleum is 0.75; that is Sp. Gr. of Petroleum : Sp. Gr. of water : : 0.75 : 1. Therefore weight of the volume of Petroleum displaced, is to weight of the volume of water displaced, as 0.75 is to 1. Expressed as follows:

$$55.5 : x :: 0.75 : 1.00$$
$$0.75\,x = 55.5 \times 1.00$$
$$x = \frac{55.5}{0.75} = 74.$$

That is, the weight of a volume of water equal to the weight of the equal volume of Petroleum displaced would weigh 74 grains. Then according to the principle of specific gravity $\frac{64}{74}$ = Sp. Gr. of the Potassium = 0.865.

4th. *Solid soluble in water, but heavier than water.*

Ex. 4. A piece of Alum weighs in air 124 grs., in Oil of Turpentine of the specific gravity 0.872 weighs 62 grs. What is its specific gravity?

Weight in air	124 grs.
Weight in Oil Turpentine	62 grs.
The loss or weight of the volume of Turpentine displaced	62 grs.

The specific gravity of the Oil of Turpentine compared with water is as 0.872 is to 1, therefore the loss or weight of displaced turpentine, is to the loss or weight of displaced water, as .872 is to 1. Expressed as follows:

$$62 : x :: .872 : 1.$$
$$0.872\ x = 62$$
$$x = \frac{62}{.872}\quad x = 71.1$$

therefore the weight of an equal volume of water is 71.1 grs.; therefore the specific gravity of Alum is $\frac{124}{71.1} = 1.74$.

HYDROMETERS.

Hydrometers are instruments for the purpose of determining specific gravities of liquids. They are generally constructed of glass, having a graduated stem and a bulb or bulbs at the lower end, loaded with mercury or shot to keep the instrument upright or in a vertical position.

The volume of the liquid displaced by the immersed part of the instrument weighs as much as the whole instrument, therefore the higher the specific gravity of the liquid, the less deep will the hydrometer sink, the lower the specific gravity, the deeper will the hydrometer sink. The point

to which it sinks in pure water, at 60° Fahr., is the zero-point. On the scale is either marked the specific gravity or it is divided into degrees.

There are two kinds of hydrometers, which may be taken as types for those of various construction.

First: Those of constant volume, but variable weight, because they are always immersed to the same extent, but carry different weights and are used to determine the specific gravity of solids and liquids.

Second: Those of variable volume but of constant weight; and are not used to determine the specific gravity, but to show whether the solutions are more or less concentrated.

Baume's hydrometer, which was the first of these instruments, may serve as type of them. The graduation of the instrument differs according to the liquid, for which it is to be used, whether heavier or lighter than water. The graduation of these hydrometers is entirely arbitrary and neither gives the densities nor the quantities dissolved.

Besides Baume's hydrometer, we have Cartier's, Gay Lussac's, Fahrenheit's, Nicholson's Saccharometer, Lactometer, Urinometer, Alcoholmeter, indicating either degrees or percentage of the respective liquids.

TABLES OF BAUME.

For liquids lighter and heavier than water. These may be found on pages 1815–6, U. S. Dispensatory. The third column to be used for the specific gravities, being recognized and adopted as standard by the Philadelphia College of Pharmacy.

TABLE OF TRALLES.

The alcoholmetrical tables of Tralles are on page 1817, U. S. Disp. The number of degrees indicate also the percentage of absolute alcohol by volume.

PROBLEMS EXPLAINING THE USE OF THE TABLES.

1st. What is the percentage of anhydrous sulphuric acid of an acid of 60° Baume? According to the table 60° B. indicates 1.705 as the specific gravity of the acid. In the table under the subject, "Sulphuric Acid," p. 107, U. S. Disp., the nearest specific gravity is 1.711, indicating 78.1% true Sulphuric Acid.

2nd. What is the specific gravity and percentage of a Sulphuric Acid of 50° B.?

3rd. What is the specific gravity of an Alcohol of 80° Tralles? What is its percentage of Absolute Alcohol by weight and by volume?

According to the table, 80° T. indicates 0.8631 as the specific gravity of the alcohol and also 80% of absolute alcohol by *volume*. In the table under the subject, "Alcohol," p. 143, U. S. Disp., the Sp. Gr. 0.863 indicates 74% of absolute alcohol by *weight*.

4th. What is the specific gravity of an Alcohol of 94° Tralles? What is its percentage of Absolute Alcohol by weight and by volume?

5th. What is the specific gravity of Aqua Ammoniæ of 16° Baume? What is its percentage of Ammonia gas?

SPECIFIC GRAVITY BOTTLE.

The simplest and best method to determine the specific gravity of a liquid is by means of the specific gravity bottle. It usually consists of a globular flask with flat bottom, slender neck, with a perforated glass stopper, accurately fitted by grinding. The bottle may hold exactly 1000 or 100 grains of distilled water at 15.5° C. A counterpoise of the exact weight of the empty bottle usually accompanies the bottle. To determine specific gravity of a liquid the following process is adopted: The liquid under operation

is brought to the temp. of 15.5° C. and then poured into the specific gravity bottle, filling it completely, and then inserting the stopper, carefully noticing that there be no air bubbles present. The excess of the liquid which overflows the bottle when the stopper is inserted is carefully wiped away and the contents of the bottle weighed. The counterpoise of the bottle is placed in opposite pan of the balance and reading weight, expressed in grains, will give the exact weight of the liquid. This weight divided by 1000 or 100 will give specific gravity of the liquid, since the same volume of water weighs exactly 1000 or 100 grains according to the bottle used. These specific gravity bottles are often known as 100 or 1000 grain bottles. Thus a 1000 grain bottle will hold 1160 grs. of hydrochloric acid, which at once indicates its specific gravity, namely: 1.16 or $\frac{1160}{1000} = 1.16$. Thus the same bottle would hold 13500 grains of mercury, indicating a specific gravity of 13.5.

The ordinary prescription vial may be used for the same purpose in the same manner, by filling the bottle with pure water to a mark upon the neck and noting the weight of water. The bottle is to be emptied and refilled to the same mark with the liquid of which the specific gravity is to be ascertained and the weight again noted. This latter weight, divided by the weight of water, will give the specific gravity Thus: A bottle holds 1050 grains of pure water, the same bottle holds 1218 grains of hydrochloric acid. Therefore according to the rule: $\frac{1218}{1050} = 1.16$ will give the specific gravity of hydrochloric acid. In this manner the specific gravity of a powder insoluble in water, may be easily determined, as illustrated by the following example:

Calomel weighs in air..... 200 grs.
A bottle holds.....1050 grs. of water.
Calomel and water weigh.....1023 grs.

By adding the calomel to the water a loss of 27 grains was produced; this loss is the weight of the bulk of water

displaced by the calomel, $\therefore \frac{200}{27} = 7.4$ specific gravity of the calomel.

Frequently it is necessary to determine the specific gravity of a liquid when neither 1000 grains flask nor marked vial are conveniently at hand. The following method may then be pursued. Ascertain the weight of a glass stopper in air, in water, and in the liquid to be tested; note the weight in each and the specific gravity is quickly determined.

The following will illustrate the method:

A glass stopper weighs in air	420 grs.
The same glass stopper weighs in water.....	200 grs.
Loss in water.....	220 grs.
A glass stopper weighs in air.....	420 grs.
The same glass stopper weighs in hydrochloric acid,	164.8
Loss in hydrochloric acid.....	255.2 grs.

therefore $\frac{255.2}{220} = 1.16$ specific gravity of HCl.

PROBLEMS.

1. A solid insoluble in water weighs 185 grains, suspended in water 165 grains; what is its specific gravity?

2. A solid lighter than water weighs in air 167 grains, a piece of metal weighs in air 108 grains; the same in water 97 grains, both together suspended in water weigh 85 grains; what is the specific gravity of the light body?

3. A bottle holds 1050 grains of water. A substance in small fragments weighs 195 grains. After it has been introduced into the bottle filled with water, the weight combined is 1225 grains, what is the specific gravity of the substance?

4. A bottle holds 960 grains of water, of chloroform 1421 grains, of aqua ammoniæ 921.6 grains; what is the specific gravity of chloroform and aqua ammoniæ?

LECTURE III.

SPECIFIC GRAVITY AND ABSOLUTE WEIGHT.

A knowledge of the laws of specific gravity furnishes a simple method for calculating the volume of a liquid when its weight and specific gravity are known, and conversely its weight, when volume and specific gravity are known.

The density of a body is the ratio of its mass to its volume, or in symbols,

$$D = \frac{M}{V},$$

D denoting density, M mass, and V volume. Thus we can establish according to the laws of specific gravity: that the specific gravity of a liquid equals the actual weight of a certain volume in air divided by the weight of the same volume of water, or represented by the formula:

$$\text{Spec. Grav.} = \frac{\text{Absolute Weight}}{\text{Volume}};$$ therefore,

absolute weight = specific gravity × volume, expressed in the *corresponding weight:*

$$\text{Volume} = \frac{\text{Absolute Weight}}{\text{Specific Gravity}};$$ expressed in the *corresponding measure.* For instance: what is the weight of 60 C. C. of distilled water at 4° C. Given the volume and specific gravity, to determine the absolute weight.

According to the rule: the actual weight would be the volume multiplied by its specific gravity. The liquid being water at its maximum density, its specific gravity is one; therefore, in symbols: absolute weight = 60 C. C. × 1; and

as a result we have, absolute weight equals 60 C. C.; to be expressed in the *corresponding weight.* The corresponding weight of the Cubic Centimeter is the Gramme; therefore the weight equals 60 grammes.

If, however, the liquid should have the specific gravity 0.96, we know that it is a liquid $\frac{96}{100}$ as heavy as water and then the weight of 60 C. C. of this liquid would be $\frac{96}{100}$ of 60 Grammes or 57.6 Grammes.

The introduction of the metric system into the U. S. Pharmacopœia, frequently necessitates the reduction from this system to the Troy and Avoirdupois Systems. The student can readily perceive the importance of a thorough knowledge of weights, measures and specific gravity.

The advantage may be demonstrated by the following problems:

Prob. 1. What is the weight of 60 C. C. of aqua ammoniæ, Sp. Gr. 0.96, the weight being expressed in the Apothecary or Troy System?

According to the rule: Abs. W. = Vol. × Sp. Gr. expressed in the corresponding weight, the Gramme, therefore: Abs. W. = 60 × 0.96 or 57.6 Grammes. This result, according to the requirements of the problem, must be reduced to the Apothecary or Troy System.

1 Gramme = 15.434 Troy grains approximately, therefore 57.6 Grammes equals 888.9984 Troy grains.

57.6
15.434

2304
1728
2304
2880
576

888.9984 grains.

By further reduction,

888.9984 grs. = ℥ i, ʒ vi, ℈ ii, 8.9984 grs.

Troy or Apothecary System:

480) 888.9984 (1 ℥
480

60) 408.9984 (6 ʒ
360

20) 48.9984 (2 ℈

8.9984 grains.

Thus we find that 60 C. C. of Aqua Ammoniæ Sp. Gr. 0.96 weigh ℥ i, ʒ vi, ℈ ii, 8.9984 grains Troy.

The following problems will further aid the student in mastering the subject:

Problem 2. What is the volume of 1 lb. Avoirdupois of a liquid, Sp. Gr. 1.16? Express in Wine and Imperial Measure.

Rule.—Vol. $= \frac{\text{Abs. W.}}{\text{Sp. Gr.}}$ expressed in the corresponding measure. Since we have no corresponding weight to the fluid ounce Wine Measure, it becomes necessary to reduce to the lowest denomination, the grain; the corresponding Measure of which, for convenience of calculation, the fluid grain. Weight = 7000 grains, specific gravity 1.16.

$\frac{7000}{1.16} = 6034.48276$ fluid grains.

Part II. To reduce 6034.48276 fluid grains to Wine Measure. The fluid ounce Wine measure contains 455.69 fluid grains, therefore, $\frac{6034.48276}{455.69} =$ fluid ounces Wine Measure.

455.69) 6034.48276 (13.242 fluid ounces Wine Measure.
45569

147758	Reduction of fractional fluid ounce.
136707	.252
	8
110512	
91138	1.936 fld. drachms.
193747	Reduction of fractional fld. drachms.
182276	0.936
	60
114716	
91138	56.160 minims.
23678	

Result: 13 fld. ℥, 1 fld. ʒ, 56+ minims Wine Measure.

Part III. To reduce 6034.48276 fld. grains to Imperial Measure.

The fluid ounce Imperial Measure contains 437.5 fluid grains; therefore, $\frac{6034.48276}{437.5}$ = fluid ounces Imperial Measure.

437.5) 6034.48276 (13.7931 fld. ounces Imperial Measure.
4375

16594	
13125	Reduction of fractional fld. ounce.
34698	.7931
30625	8
40732	6.3448 fld. drachms.
39375	
13577	
13125	Reduction of fractional fluid drs.
4526	.3448
4375	60
151	20.6880 minims.

Result: 13 fld. ℥, 6 ʒ., 20 + minims Imperial Measure.

Thus, we find that 1 pound Avoirdupois of a liquid Sp. Gr. 1.16 will measure 13 fl ℥, 1 fl ʒ, 56 · minims Wine Measure, and 13 fld. ℥, 6 fld. ʒ, 20+ minims Imperial Measure.

Problem 3. What is the absolute weight of one Liter of a liquid, 0.85 Sp. Gr.? Express in Metric, Apothecary and Avoirdupois Weight.

Rule.—Abs. W. = Vol. × Sp. Gr. expressed in the corresponding weight, the Gramme. 1 Liter, 1000 C. C. Sp. Gr. 0.85.

1000×0.85 = 850 Grammes.
850×15.434 = 13118.9 Troy or Avoirdupois grains.
$\frac{13118.9}{480}$ = 2 lbs., 3℥, 2ʒ, 1℈, 18.9 grs. Apothecary weight.
$\frac{13118.9}{437.5}$ = 29.98 oz., = 1 lb., 13 oz., 15.68 · dr. Avoir. weight.

Problem 4. What is the volume of 2 lbs. Avoirdupois of a liquid Sp. Gr. 1.40? Express in Metric and Wine Measure.

$\frac{14000.00}{1.40}$ = 10000 fluid grains, $\frac{10000}{15.434}$ = 647.92 C. C.
$\frac{10000}{455.69}$ = 21.94 fld. ounces Wine Measure = 1 pt., 5℥, 7ʒ, 35.5+ Minims Wine Measure.

Problem 5. What is the weight of 1 gallon Wine Measure of an alcohol of 0.835 Sp. Gr.? Express in Apothecary and Avoirdupois Weight.

1 gal. Wine Measure = 128 fld. ounces.
128 × 455.69 = 58316.8 fld. grains.
58316.8 × 0.835 = 48694.528 grains.
$\frac{48694.528}{480}$ = 8 lbs., 5℥, 3ʒ, 1℈, 14.528 grains Apoth.
$\frac{48694.528}{437.5}$ = 6 lb., 15 oz., 4.816 dr. Avoir. Weight.

Problem 6. What is the volume of 1 lb. Avoirdupois of Nitric Acid, Sp. Gr. 1.42? Express in Wine Measure.

Problem 7. What is the absolute weight of 1 pint, Wine Measure, of aqua ammoniæ, Sp. Gr. 0.96? Express in Apothecary and Avoirdupois Weight.

Problem 8. What is the absolute weight of 600 C. C. of Acetic Acid, Sp. Gr. 1.047? Express in Apothecary Weight.

Problem 9. What is the volume of 2 lbs. Avoirdupois of Sulphuric Acid, Sp. Gr. 1.843? Express in Metric Measure.

Problem 10. What is the volume of 10 lbs. Apothecary Weight of Nitric Acid, Sp. Gr. 1.30? Express in Imperial Measure.

Problem 11. What is the absolute weight of 1000 C. C. of a liquid, Sp. Gr. 1.000? Express in Metric Weight.

Problem 12. What is the measure of 50 lbs. Avoirdupois of an alcohol, Sp. Gr. 0.820, expressed in the Imperial, Wine and Metric Measure?

LECTURE IV.

INCREASE AND DECREASE OF SPECIFIC GRAVITIES.

The practical pharmacist is frequently compelled to adjust the densities of liquids in compounding the various pharmacopœial preparations. This is generally accomplished by the addition of water, increasing or decreasing the specific gravity as occasion may require. The importance of estimating these quantities is apparent and requires a thorough understanding of weights and measures and specific gravity. It must be borne in mind that the calculations following hereafter are based on water at a temperature 4° C. and under the barometric pressure 760 millimeters. For all practical purposes these calculations are sufficiently accurate, making no allowance for contraction or expansion, increase or decrease of temperature, produced by the admixture. Temperature may with careful manipulations be regulated, expansion or contraction not so readily, although when the coefficient of expansion is known, corrections are easily calculated.

The subject is considered under two divisions: 1st, Liquids specifically heavier than water. 2nd, Liquids specifically lighter than water.

1st. Reduction of liquids of a higher specific gravity than water, by the addition of water to a lower specific gravity. For instance, to reduce the Sp. Gr. of 1 Liter of a liquid from 1.35 to 1.30 by the addition of water. How much water is necessary?

To 1 Liter of a liquid of 1.35 Sp. Gr. add x Liters (any unknown number of Liters) of water to bring the liquid

to the specific gravity of 1.30. The volume of the liquid after dilution will be (1 + x) liters, having a Sp. Gr. 1.30. The absolute weight of this liquid, according to the foregoing principles, Abs. W = Vol. × Sp. Gr. will be (1 + x) 1.30 expressed in Kilogrammes, the corresponding weight of the Liter. For the same reason 1 liter or 1 volume of the liquid of 1.35 Sp. Gr. will weigh 1.35 Kilogrammes.

The absolute weight of x liters of water will be x Kilogrammes, therefore the absolute weight of the diluted liquid will also be 1.35 + x Kilogrammes. Then the following equation must be correct:

1.35 + x = (1 + x) 1.30: since both sides represent the absolute weight of the diluted liquid. Eliminating and transposing we find that

$$\begin{aligned} 1.35 + x &= 1.30 + 1.30\,x \\ 0.05 &= 0.30\,x \\ \frac{.05}{.30} &= x \end{aligned}$$

x = 0.166 expressed in liters: since x represents volume and not weight. Therefore to 1 liter or to 1 volume of the original liquid, $\frac{166}{1000}$ liters or $\frac{166}{1000}$ of one volume of water are to be added, to reduce the Sp. Gr. to 1.30. Expressed in the lowest denomination, the cubic centimeter, which is $\frac{166}{1000}$ of $\frac{1000}{1}$ = 166 C. C. Consequently 166 C. C. of water are necessary to reduce the Sp. Gr. of 1 liter of a liquid from 1.35 to 1.30.

From the preceding calculation we can formulate the following rule: To reduce the Sp. Gr. of liquid, higher than water by the addition of water. 1st, subtract the number giving the lower specific gravity from the number giving the higher one, call this A; 2nd, subtract the number one from the number giving the lower specific gravity, call this B; 3rd, divide A by B, call this C. The quotient obtained expresses the *number of volumes* or a *fraction thereof* of

water to be added to *each* of the *volumes* of the liquid to be diluted.

PROBLEM BY RULE

How much water is necessary to reduce the specific gravity of 1 liter of a liquid from 1.35 to 1.30?

1.35 number giving the higher Sp. Gr.
1.30 " " " lower " "

.05 result, call A.

1.30 number giving the lower Sp. Gr.
1.00 " One.

.30 result, call B.

$$\frac{A}{B} = C = \frac{.05}{.30} \quad C. = 0.166$$

The quotient represents the number of volumes or fraction thereof of water to be added to each of the volumes of the liquid to be diluted.

The number of volumes of the original liquid is 1 liter or 1000 C. C. and to each volume, $\frac{166}{1000}$ of one volume is to be added, therefore $1000 \times \frac{166}{1000} = 166$ C. C. of water is to be added.

Problem 2. How much water is to be added to reduce the Sp. Gr. of 10 fld. ounces of a liquid from 1.50 to 1.20?

RULE:

1.50	1.20	$\frac{A}{B} = C.$	$\frac{.05}{.30} = C.$
1.20	1.00		
.30 A	.20 B		

C = 1.5, number of volumes 10, expressed in fluid ounces. Number of volumes of water to be added 10 x 1.5 = 15 fluid ounces. An important factor in calculating the quantity of water must always be borne in mind, that the quantity of water to be added is expressed in volumes, and is to be added to volumes. Whenever the liquid to be

reduced is expressed by weight, it is necessary to reduce the weight to its corresponding volume, before the addition of water can be made.

PART 2. To increase the Sp. Gr. of a liquid by the addition of water. The principles involved are identical with those illustrated in the foregoing problems. The general rule being slightly modified.

Problem 1. How much water is necessary to increase the Sp. Gr. of 12 fluid ounces of a liquid, Sp. Gr. 0.89 to 0.95, by the addition of water?

To 12 fluid ounces add x ounces of water to increase the Sp. Gr. from 0.89 to 0.95. The volume of the liquid after addition of water will be $(1 + x)$ ounces having the Sp. Gr. 0.95. The absolute weight of which will be $(1 + x)\ 0.95$ expressed in ounces, either Avoirdupois or Troy, depending on the measure of the liquid of which the specific gravity is to be increased, imperial or wine measure respectively.

The absolute weight of 12 fld. ounces or one volume of a liquid Sp. Gr. 0.89 will be 0.89 expressed in ounces by weight, either Avoirdupois or Troy according to the denomination of the original liquid.

The absolute weight of x ounces or x volumes of water will be x ounces by weight. Accordingly the absolute weight of the diluted liquid may either be expressed by $(1 + x)\ 0.95$, or, by $0.89 + x$. Both representing the absolute weight must be equal to each other; therefore $0.89 + x = (1 + x)\ 0.95$.

Eliminating the equation we find $x = 1.2$. This result, (1.2) representing the number of volumes of water to be added to each volume of the liquid to be increased in Sp. Gr. The original liquid measured 1 volume or 12 fluid ounces; therefore, 1.2 volumes or 14.4 fluid ounces of water must be added to increase the specific gravity from 0.89 to 0.95. It must again be remembered that the quantity of water to be added is expressed in volumes and not in

weight. The following simple rule will be applicable, whenever the specific gravity of liquids is to be increased by the addition of water.

RULE I.—Subtract the number giving the lower specific gravity from the number giving the higher one; call this "Á."

II.—Subtract the number giving the higher specific gravity from the number "one"; call this "B́."

III.—Divide Á by B́; call this Ć. The quotient obtained expresses the *number of volumes* or *fraction thereof* of water to be added to *each* of the *volumes* of the liquid of which the specific gravity is to be increased.

PROBLEM BY RULE.

How much water is necessary to increase the specific gravity of 12 fluid ounces of a liquid from 0.89 to 0.95.

0.95 number giving the higher Sp. Gr.
0.89 number giving the lower Sp. Gr.

0.06 result, call Á.

1.00 number "one."
0.95 number giving the higher Sp. Gr.

.05 result, call B́.

$$\frac{Á}{B́} = Ć. \quad \frac{.06}{.05} = 1.2$$

$1.2 \times 12 = 14.4$ fluid ounces of water to be added.

It will be seen that Rule I and II are almost identical, the only difference being between B and B́.

The same principle may be applied whenever weight is given instead of volume; provided, however, that the weight is reduced to the corresponding measure. So far the volume of liquids has been given and consequently there was no necessity for reduction. The following

problems are given with a view of more clearly demonstrating the manner of calculating the desired quantity of water.

1. How much water is necessary to increase the specific gravity of 8 oz. Avoirdupois of a liquid from 0.90 to 0.97 by the addition of water? Express in Apothecary weight and measure. Vol. $= \frac{\text{Abs. W.}}{\text{Sp. Gr.}}$ Weight 8 oz. Avdp. Sp. Gr. 0.90. Vol. $= \frac{3500}{0.90} = 3888.888$ fluid grains Wine or Imp. Measure, since the fluid grain is the same in both systems of measure.

RULE 2.

0.97	1.00	$\acute{A}$	C.	$\frac{.07}{.03} = 2.33+$
0.90	97	$\acute{B}$		
.07 $\acute{A}$	0.03 $\acute{B}$			

Thus, 2.33 fluid grains of water must be added to each fluid grain of the original liquid; therefore, the whole quantity will be represented by $3888.888 \times 2.33 = 9061.10904$ fluid grains water, Wine or Imperial Measure. These fluid grains reduced to Apothecary Measure, $\frac{9061.10904}{455.69} = 19.884+$ fld. ℥, equal to 1 pt., 3 ℥, 7 ʒ, 4+ minims, the weight of 9061.10904 fld. grains in the Apothecary System is the same, since the Sp. Gr. is one; therefore, $\frac{9061.10904}{480} =$ 1 lb., 6 ℥, 7 ʒ, 1.10904+ grs., expresses the Apothecary Weight.

2. The same, expressed in Avoirdupois and Imperial Measure.

Imperial measure $\frac{9061.10904}{437.5} = 20.7111+$ fld. oz. = 1 pt., 5 fld. dr., 41+ minims.

Avoirdupois weight, $\frac{9061.10904}{437.5} = 20.7111$ oz. = 1 lb., 4 oz., 11 dr., 10+ grains.

Ex. 2. In the formula for the preparation of Citrine Ointment, 3½ ounces of Nitric Acid is to be used. Nitric

Acid of the proper strength (1.42 Sp. Gr.) is not on hand, an acid of 1.39 Sp. Gr. has to be used. How much of this acid would be necessary to be equivalent to $3\frac{1}{2}$ ounces of the stronger acid?

Ex. 3. The following prescription is presented and to be prepared:

℞ Acid Phosph. Germ. Phar. fld. ʒ ii
Syr. Simpl. fld. ℥ i
Aqua dest. q. s ad ʒ iii
Mft.

Phosphoric Acid of the German Pharmacopœia has the specific gravity 1.12; this acid is not on hand, but one of 1.056 Sp. Gr. How much of this acid is necessary, and how should the prescription be prepared?

Ex. 4.

℞ Liq. Ferri sesquichlorid. G. P. ʒ ii
Syr. Citri fld. ℥ i
Aqua dest. fld. ʒ ii
Mft.

Liq. Ferri sesquichlorid. Germ. Pharm., has the Sp. Gr. 1.484; that of the U. S. Phar. has the Sp. Gr. 1.355; how many grains of the U. S. liquor are necessary to obtain an equivalent quantity?

LECTURE V.

SPECIFIC GRAVITY AND PERCENTAGE.

It is desirable on many occasions, both in chemical and pharmaceutical operations, to know the quantity of absolute matter contained in the same liquid of different densities. The influence which the addition of water has on liquids, increasing or decreasing their specific gravities, has been clearly demonstrated in the preceding chapter. It must be apparent that the specific gravity of a liquid is a criterion for its strength. The U. S. Dispensatory contains many tables showing from the specific gravities, the percentage of absolute matter contained in 100 parts by weight. The specific gravity being determined at a temperature of 15° C. The exceptions to the general rule being Acetic Acid, in which the same specific gravity indicates different percentages of anhydrous acid; also, Hydrocyanic Acid and Tinct. Chloride Iron.

Ex. 1. How much water is necessary to reduce 1 lb. Avoir. of stronger alcohol U. S. 1870 to alcohol U. S. 1870?

By referring to the table of Specific Gravities under Alcohol, we find that STRONGER ALCOHOL and ALCOHOL contain respectively 92% and 85% of absolute alcohol by weight. According to the meaning of the term percentage, every 100 parts of stronger alcohol contains 92 parts of absolute alcohol, then 7000 parts or grains must contain $\frac{92}{100}$ of $\frac{7000}{1}$ parts of absolute alcohol, which is 6440 grains and indicated by the following proportion:

100 : 92 : : 7000 : x; 100 x = 644000; x = 6440 absolute alcohol.

Again, every 100 parts of alcohol contain 85 parts of absolute alcohol, then 6440 parts or grains of absolute alcohol must be contained in $\frac{100}{85}$ of 6440 parts of alcohol as per following proportion:

$$85 : 100 :: 6440 : x;\ 85x = 644000;\ x = 7576 \text{ parts or grains of alcohol.}$$

Therefore, 7000 grains of stronger alcohol U. S. 1870, will produce 7576 grains of alcohol U. S. 1870; consequently 7576—7000 = 576 grains of water must be added.

Ex. 2. How much water is necessary to reduce 1 lb. Avoirdupois of Sulphuric Acid of 97% to 90%? Reasoning as before, we obtain the following proportions:

$$100 : 97 :: 7000 : x.\quad x = 6790 \text{ grains, Anhydrous acid.}$$
$$90 : 100 :: 6790 : x.\quad x = 7544 \text{ grains,}$$

Of a Sulphuric acid of 90%, therefore 7544 — 7000 = 544 grains of water are necessary.

Ex. 3. How much Sulphuric Acid of 97% is required for 1 lb. Avoirdupois of 90%?

Ex. 4. A sample of Commercial Alcohol has the Sp. Gr. of 0.816 and contains 94% by volume of absolute alcohol; how much of this alcohol is required to make one gallon Wine Measure of an alcohol of 85%? Express in Wine Measure.

Ex. 5. How much alcohol of 94% by volume is required for 1 Liter of an alcohol of 60% by volume?

LECTURE VI.

WATER AND HEAT.

Water covers about three-fourths of the surface of our earth; it exists as a solid at the poles, as a fluid in warmer regions; it rises in vapor into the air, forming clouds, and returns as a fluid in rain to the earth.

Thus we find it in nature in its three aggregate forms and it is obvious that these external differences have been effected by the agency of heat. Hence, water is peculiarly well adapted to serve as a study for the most important effects of heat.

Heat expands all bodies, those in aeriform state by far the most, in the liquid state less, and all solids less than fluids.

No two solids expand alike; the metals expanding the most.

TEMPERATURE.

The word temperature is used to denote the state of a body with respect to sensible heat.

The expansion of water may be noticed by filling a flask with water at the normal temperature and closed by a perforated cork in which a narrow glass tube has been inserted, so that the water may stand a little above the cork in the tube. By applying heat we can easily perceive the rise of water in the tube. If a very narrow tube is selected, very slight changes of space are rendered visible and these deviations may be applied to the measurement of heat. As we can only perceive heat by means of its effects upon bodies,

we must make use of some of these as a means of measuring it. Water and liquids generally, undergoing rapid changes at their freezing points, or solids near their melting points, are not well adapted to measure temperature by their change in volume. Atmospheric air, which is incapable of being condensed into a liquid by most extreme cold, is admirably adapted for the purpose of measuring temperature so far as accuracy is concerned. For all general purposes, mercury has been found to be the most practicable.

THERMOMETER.

An instrument for measuring temperature. The thermometer usually consists of a glass tube of capillary bore, terminating in a bulb and containing mercury or alcohol, which, expanding or contracting according to the temperature to which it is exposed, indicates the degree of heat by the position of the top of the liquid column on a graduated scale. Water might be employed for measuring heat by marking the boiling and freezing points and graduating the intervening space; but mercury is better adapted to the purpose, as it boils and freezes at greater extremes of temperature and more readily denotes the variations of heat. Mercury freezes at—40° C., and boils at 360° C.; its extremes are 400° C. apart; those of water only 100° C. Alcohol is used for extreme low temperature, as it does not congeal at —100° C.

CONSTRUCTION OF THERMOMETERS.

In order to make a mercurial thermometer, take a glass tube having a capillary bore with a bulb blown at one end of it, the other end being open so that the bulb and tube are filled with air. Heat the bulb over a lamp, in consequence of which the air in the bulb will expand, and

part will be driven out at the mouth of the tube. Next, before the bulb begins to cool, let the mouth of the tube be plunged beneath the surface of a vessel filled with pure mercury. During the process of cooling, the air left in the bulb will contract, and the pressure of the atmosphere will cause the mercury to rise in the tube until part of it gets into the bulb. Having by this means got some mercury into the bulb, boil the mercury in the bulb until the bulb and tube are filled with the vapors of mercury; when this cools there will be a vacuum, and the mercury into which the instrument is plunged will be driven up by the atmospheric pressure until the bulb is filled. When bulb and tube have been filled by this process, the tube is hermetically sealed, and when cool the mercury will fill the bulb and parts of the tube, the other part being empty. By heating this instrument we expand both glass and mercury, but the mercury will expand more than the glass and consequently the mercury will rise in the tube or stem. In like manner, on cooling the instrument, mercury will contract more than glass and consequently will sink or fall in the stem. Thus, if the bore of the stem be very fine, a large rise of mercury may be caused by a small elevation of temperature.

DETERMINATION OF FIXED POINTS.

Having thus constructed the instrument, the next operation is to mark off on the stem the heights of the mercurial column corresponding to the freezing and boiling points of water. To ascertain the freezing point, the instrument is placed into some melting ice for about a quarter of an hour. A mark is then scratched on the stem at the termination of the mercurial column.

To obtain the boiling point, the instrument is immersed in steam arising from boiling water at a pressure of 760

millimeters. The height of the mercurial column is likewise marked on the stem. These two points are respectively the freezing and boiling points.

In the Celsius or Centigrade scale, the freezing point is zero, or 0°, and the boiling point 100°. In general the graduations are extended from somewhat below the freezing point to somewhat above the boiling point, those below 0° being reckoned negative; as for instance —1°, and so on.

In the Fahrenheit scale, the freezing point of water is termed 32°, and the boiling point 212°. In the Réaumur scale, the freezing point is 0° and the boiling point 80°. Having ascertained the two fixed points, the next step is to graduate the instrument. If the bore of the capillary tube be of uniform size throughout, the divisions denoting degress will be equal in length, and if the centigrade scale be adopted there will be one hundred divisions; in the Fahrenheit scale 180 divisions, in the Réaumer 80 divisions. Thus it will be seen that the degrees of Réaumer, Celsius and Fahrenheit are to each other as 4, 5, 9, respectively. The thermometer of Réaumer is used in Germany, the Celsius or centigrade thermometer in all scientific works, Fahrenheit thermometer in the United States and England.

The following illustration will clearly demonstrate the scales on the thermometers:

	Fahrenheit Scale.	Centigrade or Celsius Scale.	Réaumur Scale.
Boiling point,	212	100	80
Freezing point,	32	0	0
	0		

The conversion from one system to another is illustrated by the following examples:

I. Convert 12° C. to F.

$$5 : 9 :: 12 : x$$

$x = 21.6°$; that is 21.6° above the freezing point; the freezing point being 32°; then 21.6° + 32° = 53.6° will be the corresponding degree of Fahrenheit.

II. Convert —3° C. to F.

$$5 : 9 :: 3 : x$$

$x = 5.4°$ below the freezing point of Fahrenheit, therefore, $32° - 5.4 = 26.6°$.

III. Convert —18° C. to F.
IV. Convert 10° R. to F.
V. Convert —5° R. to F.
VI. Convert —20° R. to F.
VII. Convert 60° F. to C. and R.
VIII. Convert 14° F. to C. and R.
IX. Convert 10° F. to C. and R.
X. Convert 32° F. to C. and R.
XI. Convert 15° C. to R. and F.
XII. Convert 12° R. to C. and F.

LECTURE VII.

PHARMACY.

Pharmacy, at the present day, is considered to be the art or practice of preparing, preserving and compounding substances for the purpose of medicine.

Like other sciences, it is one of a miscellaneous nature, and involves Materia Medica, Therapeutics, Botany, Chemistry, Physics and Mathematics. The practical pharmacist is required to possess some knowledge of the previously named subjects for the intelligent study and practice of the art.

PHARMACOPŒIAS.

All civilized nations have recognized the necessity of some standard to define the character, establish tests for identity and purity, and to regulate the strength of all substances used for the purpose of medicine. This standard is known as the Pharmacopœia; it denotes a book containing directions for the identification of simples and the preparation of compound medicines; published by the authority of the government, or a medical or a pharmaceutical society. The first book of this nature was published by the authority of the government, at Nuremberg, in the year 1542. The first book with the title of Pharmacopœia was published at Basel, in the year 1561. Until the year 1617, such drugs and medicines as were in common use, were sold in England by the apothecary and grocer. In that year, the apothecary obtained a separate charter; grocers were no longer permitted to dispense; the preparing of prescriptions was

confined to the apothecary. To obtain a uniformity of preparations, the physicians were finally induced to adopt some regular system, and which resulted in the publication of the London Pharmacopœia, in the year 1618. Further issues appeared in 1621,–32,–39,–77, without any definite changes until the year 1721; the next revision being made in the year 1788. The first Edinburgh Pharmacopœia was issued in 1699; the last in 1841.

The issues of the Dublin Pharmacopœia extending from the year 1807 to 1850. These different Pharmacopœias issued under one government created considerable confusion and produced many errors; and necessitated the publication of a Pharmacopœia of the United Kingdom. This was known as the British Pharmacopœia, published in the year 1864, revised in 1867, and the latest issue being that of the year 1885. The first Pharmacopœia of the United States was published in the year 1820; through some misunderstanding, two were published in 1830; since that time the Pharmacopœia has undergone a revision every ten years; the last issue being the Sixth Decennial Revision, published in 1882.

It is of importance to clearly understand the significance of every term used, in order to form a proper conception of the study of pharmacy. It is not the intention of a work of this nature to enter into details of those laws which regulate the phenomena of nature, but merely give a brief review with definitions of some of the more common terms. Pharmacy as stated, treats of substances. Any thing which has extension, occupies space, or is perceptible by the senses is considered matter, a body or a substance. Many of the substances with which we are acquainted are capable of appearing before us in three different states. They are either solid, liquid, or aeriform, and each of these states in which substances exist is called their state of aggregation; a union of like bodies.

The forces, as they are exhibited in the three states of matter require a brief description. The first of these is Cohesion.

To divide a piece of ice into smaller fragments, a greater force is required than to separate water into minute portions, whence we infer, that the particles of ice are attracted more strongly than those of the fluid water. A certain attracting power is regarded as the cause of this difference; it acts on the smallest particles and is called Cohesion or Homogeneous attraction.

In solid bodies this attraction is greater or stronger than in liquids; in aeriform bodies hardly a trace of this force can be perceived. While cohesion is a force which causes like particles to cling into one mass; adhesion is a force which causes particles of different kind of matter to cling together without changing the nature of either. If however, the particles of different bodies have such an attraction for each other, so as to form a substance different in nature of either, then we call this force Chemical Affinity.

Forces which tend to alter the shape of solid bodies will be resisted by forces in the bodies themselves; thus giving rise to the properties: Tenacity, Ductility, Malleability, Brittleness, Hardness, and Elasticity.

Tenacity.—When the forces tending to rupture a body is one directly tending to pull its particles asunder, the resistance which it offers to this is termed its tenacity.

Ductility denotes the property of bodies, in virtue of which they permanently change their form under the application of stretching force.

Malleability is a modification of ductility. Some bodies do not stand being drawn out into wire, but they may be hammered into thin plates.

Brittleness, a force the opposite of tenacity. A body is said to be brittle when it is wanting tenacity.

HARDNESS is that property, in virtue of which a body resists the action of another tending to scratch its surface.

ELASTICITY is a property in virtue of which a body has a tendency to recover its former shape when the pressure exerted upon it is removed.

OPERATIONS IN PHARMACY.

Almost every solid substance used in medicine requires, at some time, to undergo some mechanical division to fit it for direct medicinal use, or for some subsequent process. The nature of this division and means by which this is effected, will vary according to the physical nature of the substance.

LECTURE VIII.

COMMINUTION—VEGETABLE MATTER.

All substances of vegetable origin should be cut transversely to the direction of the vascular and fibrous tissue and in thin slices. It is obvious that from the nature of the growth of a plant, that a transverse section will open every cell and duct of the part used, whether it be a root, rhizome, tuber, bulb, or twig, and even barks might be included.

Hence, the parts used are better adapted for subsequent drying and preservation, as squill and calumbo; it also facilitates the extraction of the medicinal properties by water or other menstruum. In order to obtain the juices of plants, it is necessary to make a transverse section, since it affords the largest number of outlets for the juice when the parts are expressed.

Lastly it avoids the presence in various preparations, as infusions and decoctions, of inert matter contained in the cells of the interior, as in sarsaparilla, where the starch is confined almost entirely in the central portion, and hence is not extracted from the root when cut transversely. This slicing of vegetable matter is accomplished by instruments simple in structure and generally consists of a one-armed lever with knife attachment and fastened to a block by a hinge, so that the lever can be moved in a vertical direction through a screw adjustment, whereby the thickness of the cross section of the plant under operation can be increased or decreased as the circumstances may require. The knife should be very sharp to prevent tearing of cellular structure and loss of juice.

This comminution or reduction to finer particles must be accomplished to a still greater degree to adapt vegetable matter to subsequent processes.

The greater part of vegetable drugs which are used in powder form are reduced to that state before they enter the shops of the pharmacists, by persons who make it their special business. The operations are performed on a large scale by means of mills of various construction and other necessary accompaniments to complete the processes of bruising, grinding and sifting. If performed on a small scale by the pharmacist, the process is considered one of pulverization and is accomplished by the means of mortar, pestle and sieve. In order to accomplish pulverization of vegetable drugs, on a large or small scale, it is necessary that they be thoroughly dessicated; the presence of water making the substance pliable and tough, its absence brittle and friable.

The fineness of powder is expressed in the Pharmacopœia by terms expressing the number of meshes to a linear inch in the sieve. These different forms of expression correspond to each other as follows:

A very fine powder. { Should pass through a sieve having 80 or more meshes to the linear inch. No. 80 powder.

A fine powder. { 60 meshes to the linear inch. No. 60 powder.

A moderately fine powder. { 50 meshes to the linear inch. No. 50 powder.

A moderately coarse powder. { 40 meshes to the linear inch. No. 40 powder.

A coarse powder. { 20 meshes to the linear inch. No. 20 powder.

These degrees of fineness are necessary to meet the requirements of the various conditions of the drug.

Some drugs, as Nux Vomica, are very hard and compact,

and not easily penetrated by the menstruum and must be very finely powdered to facilitate the extraction of the medicinal principle.

Resinous drugs, as Jalap, Gamboge, Podophyllum, when intended for administration in substance, acquire increased activity the more finely divided; since an increased surface is offered for absorption of active constituents.

Drugs which do not swell when moistened with a menstruum should be finely powdered to favor the solution of soluble constituents, while those which expand considerably when moistened must be used in as coarse a powder as possible to prevent the stoppage of the menstruum used for exhausting them. Drugs as Cinchona and Cascarilla, in which the soluble constituents are not readily absorbed by the menstruum, must be in a finer state of division to gain that portion on which the activity depends.

Drugs intended for infusions and decoctions should be in coarse powder so as to obtain clearer solutions. Thus, most vegetable substances expand more readily under the influence of water than alcohol, therefore the drug shou'd be finer for tinctures; hot water causes more rapid expansion than cold, therefore for decoctions the drug may be still coarser.

EFFECT OF PULVERIZATION.

It is obvious that in the process of pulverization, as accomplished in the various manipulations of Dessication, Bruising, Grinding and Sifting, many changes must take place, increasing and decreasing the strength, depending on the nature of the crude drug, proving in some cases advantageous, while in others the very opposite of the desired.

The combined processes produce a decrease in the strength of the drug by the loss of volatile oil and other volatile active constituents as in case of Asafœtida and all aromatic herbs. Decrease by increased oxidation of active constituents due

to the extended surface exposed to air, as in Myrrh, the volatile oil, if not dissipated by drying, rapidly becomes oxidized to resin; oily seeds, the fixed oils soon become oxidized, rancid and irritating by the absorption of oxygen, as with flax seed.

Decrease by the influence of heat during drying and grinding generated by the friction of the grinding surfaces. Decrease by the influence of heat during drying, as in Hyoscyamus, Digitalis, also the disintegration of starch, coagulation of Albumen.

Decrease by the loss of fixed oil by pressure of the grinding surfaces.

There is an increase of strength by the loss of moisture incurred during drying necessary before pulverization, as with Gentian.

Increase by the separation of inert matter in the form of gruffs, such as the fibrous part of ginger, the woody tissue of ipecac, husks of mustard and cardamon thrown aside in process of sifting.

In case of mustard and cardamon, there may be increase and also decrease by the loss of volatile oil. All vegetable matter contains starch, consisting of granules of matter soluble in water, but covered with a skin so hard and impenetrable that it requires great force to break these and then become soluble in water.

Whenever starch from Amylaceous seeds, tubers, rhizomes and palm stems is desired, the pulverization of the vegetable matter must be accomplished on a large scale, that is by means of mills. The degree of fineness of many vegetable powders may be ascertained by the intensity of the iodine re-action on starch. Whenever it is desired to avoid the action of starch, the vegetable drug should be in coarse powder.

PULVERIZATION.

Trituration.—This is a process of reduction to finer particles and to mix different substances together. This is accomplished by mortar and pestle, as in the pulverization of calomel in crusts, or the class of preparations introduced in Pharmacopœia, 1880, "Triturations."

Levigation.—This is a process of reduction to finer particles by rubbing, previously made into a paste with water. This is accomplished with a ground glass surface and muller, as in the pulverization of oyster shells, coral, chalk, red oxide of mercury. The pulverization of Salep, Nux Vomica and St. Ignatia bean, is also accomplished by the process of levigation. Salep is macerated in cold water until soft, then rapidly dried and powdered in a flat mortar with flat pestle. Nux Vomica and St. Ignatia bean are exposed to the action of steam until swelled to twice their size, then dried rapidly and powdered. In the Salep, the starch granules are softened by water, which could not be done with Nux Vomica and St. Ignatia bean without the loss of active constituents, strychnine and brucine.

Mediation.—This is a process of reduction to finer particles by the addition of another medium, accomplished by mortar and pestle, as in the pulverization of camphor with alcohol, spermaceti with alcohol, agaric with mucilage of tragacanth.

Pulverization by Precipitation.—A reduction to finer particles by throwing out of solution by decomposition, as in the pulverization of Carbonate and Phosphate of Calcium. These are brought into solution by the aid of Hydrochloric Acid, and thrown out of solution by Carbonate of Sodium in a fine state of division.

Pulverization by Granulation.—A process of reduction to finer particles by forming small granules and then using

mortar and pestle. This is accomplished in various manners. 1. By bringing a chemical substance in solution with water and evaporating the water under constant stirring, as Sal Ammoniac.

Zinc as obtained, in blocks, is rather brittle but tough enough to resist the attempt to powder. Heated to about 300° F. it becomes malleable and may be rolled into sheets, at 400° F. very brittle and may be powdered; therefore to powder zinc, melt it and pour it into a hot iron mortar and triturate until cold.

Tin can be powdered in the same manner, by melting and pouring in a box coated or dusted with chalk. Granules of tin are formed which by trituration may be reduced to a very fine powder. The adhering chalk is removed by washing with water or dilute hydrochloric acid. Gold and silver in the form of leaves are triturated with honey and the latter washed out with water.

Iron reduced to granules by the file and then trituration; or by chemical means.

$$Fe_2\ O_2\ (HO)_2 + 3H_2 = Fe_2 + 4H_2\ O.$$

By passing dry hydrogen gas over heated sub-carbonate of iron, obtaining iron in a very fine state of division.

Gold and silver may be likewise obtained in powder form by chemical decomposition.

$$2\ Au\ Cl_3 + 6\ Fe\ S\ O_4 = Fe_2\ Cl_6 + 2\ Fe_2\ 3\ SO_4 + Au_2$$

Complete reduction of Gold.

Silver Chloride is boiled with honey and a solution Caustic Potassa, silver being obtained in powder form.

Ellutriation.—The process of removing the coarser from the finer, or the heavier from the lighter particles. This process is auxiliary to the process of Granulation and Precipitation.

Decantation and Washing.—A process of separating solids from liquids, and consists in allowing the solid to settle

and pouring off the liquid slowly without agitating the deposit. In washing precipitates the process is employed as in the preparation of Precipitated Chalk. The effect produced is illustrated in the following: Take 95 grs. fused chloride calcium and 245 grs. of crystalized carbonate of sodium, each dissolved in 25 ounces of water. Mix the two solutions and add sufficient quantity of water to make the product measure 100 fluid ounces. The product will contain 85 grs. carbonate of calcium in suspension, and 100 grs. chloride of sodium in solution, therefore each fluid ounce will contain 1 gr. chloride of sodium.

Allow the precipitate to settle and pour off 95 fld. ounces, the balance will contain 5 grs. salt in 5 fld. ounces, add 95 fld. ounces of water, shake well and allow the precipitate to settle, then each fld. ounce will contain $\frac{5}{100} = \frac{1}{20}$ gr. of salt; pour off 95 fld. ounces, the remainder will contain $\frac{5 \times 1}{20}$ gr. Na. Cl. Bring again to 100 fld. ounces, then each fluid ounce will contain $\frac{1}{100}$ of $\frac{1}{4} = \frac{1}{400}$ gr. of salt; after settling, pour off 95 fld. ounces, the remainder will contain $\frac{5 \times 1}{400} = \frac{1}{80}$ gr. of salt; add 95 fld. ounces again, each fld. ounce will contain $\frac{1}{8000}$ gr. of salt; continue in the same manner until completely purified. In decanting, care must be taken not to disturb the deposit nor allow the liquid to run down the sides of the vessel. This can be avoided by greasing the lip of the vessel and by using a glass rod as a guiding rod. Syphons and Pipetts of various construction are also used for the same purpose.

LECTURE IX.

SOLUTION.

The process or operation in which a substance placed in contact with a liquid disappears or takes to the fluid state and becomes intimately mixed with the liquid, is termed solution. The liquid used to effect the change is called the solvent or menstruum, and the product a solution.

Solution is not confined to solids, as fluids and gases may dissolve in liquids. Solution may be of two kinds: 1. Simple. 2. Compound.

1. Simple solution is one in which a body when dissolved retains its physical (except external form) and chemical properties, and is recoverable by evaporation, as sugar or salt dissolved in water.

2. Compound solution is one in which a body when dissolved loses its sensible and chemical properties; that is, chemical action takes place between the solvent and the substance, before which action, solution could not have taken place and after which, the properties of both have changed, as the solution of metals in acid.

Solution is facilitated by mechanical division; that is, a solid in a fine state of division offers greater surface to the solvent, and which by stirring comes more in contact with fresh portions of the solvent. The Specific Gravity increases the solvent power of a liquid; that is, when a body is suspended in the solvent, the parts in contact with the solid become denser, sink and produce a current, and bringing fresh portions of the solvent in contact with the solid continually, increasing the rapidity of solution.

Heat facilitates solution, since most bodies are more soluble

in hot than in cold liquids; and furthermore, is productive of currents which constantly offer fresh surfaces of the solvent to the solid.

SATURATION. A solution is said to be saturated when the menstruum does not take up or dissolve any more of the substance at the common temperature. This process of solution is called saturation.

A solution that is saturated with one solid is still able to take up another, and on this principle the purification of many salts depends.

Solution is governed by certain laws.

1. The nearer the point of saturation the slower or tardier will be the process of solution.

2. Any cause that retards evaporation favors the accummulation of heat and saving of menstruum, and therefore increases the solvent power of the menstruum.

3. Whenever a solid dissolves rapidly without chemical action, a reduction of temperature takes place, and consequently decreases the solvent power of the menstruum. The so-called freezing mixtures depend upon this principle; that is, sensible heat becomes latent, or a quantity of heat is absorbed when bodies pass from the solid into the liquid, or from the liquid into the gaseous state.

4. Whenever a substance is dissolved, accompanied with chemical re-action, heat is generated and often effervescence, change of color, odor and taste attend solution. In solution of this kind, the important points requiring attention are:

I. Degree of division of the substance to be dissolved.

II. Degree of concentration of the solvent.

III. The temperature at which solution is affected.

According to these the re-action may be increased or decreased.

IV. Whenever effervescence takes place, means must be employed to prevent the loss of part of the solvent by being carried up with the vapors.

Solvents. The solvents used in pharmacy are water, alcohol, ether, chloroform, acids, glycerine and oils, wine, vinegar.

DIVISION OF SUBSTANCES.

Substances submitted to the action of solvents are divided into two classes: Homogeneous and Complex substances. Homogeneous substance is one in which the particles composing it are all of the same nature, such as salt, sugar, etc. Complex substance is one in which the particles composing it are all of different nature, such as barks, roots, herbs. The former produce simple, the latter complex solutions. The apparatus necessary for complex solutions are the mortar and pestle, macerating jars and press, infusion and decoction mugs and percolators.

COMPLEX SOLUTIONS.

SOLUTIONS OBTAINED FROM COMPLEX SUBSTANCES.

The extraction of complex substances by a solvent or menstruum is accomplished by various processes, namely: Maceration, Infusion, Decoction, Digestion, and Percolation.

MACERATION.

The process of maceration consists in subjecting a complex substance, composed of soluble and insoluble matter in a divided state, to the action of fluids at the normal temperature for a greater or less period of time until the soluble part has been ceeded to the menstruum. This is accomplished by placing the drug in wide-mouthed jars, pouring on the solvent, corking tightly, and setting aside from 2 to 14 days, agitating occasionally. After the proper period of time, the liquid is poured off, the residue expressed and the combined liquids filtered. The temperature ranges between 60°—90° F. The process is directed by the German Pharmacopœia in the

preparation of all tinctures, while in U. S. Phamacopœia, the process is generally displaced by the process of percolation.

INFUSIONS.

The process consists in subjecting a complex substance, composed of soluble and insoluble matter in a divided state, to the action of cold or boiling water for a specified time. The infusions of the Pharmacopœia are prepared by maceration and percolation.

The general formula of the Pharmacopœia is as follows: An ordinary infusion, the strength of which is not directed by the physician, nor specified by the Pharmacopœia, shall be prepared by the following formula:

Take of the substance, coarsely comminuted, ten parts,	10
Boiling Water, one hundred parts,	100
Water, a sufficient quantity,	
To make one hundred parts,	100

Put the substance into a suitable vessel, provided with a cover, pour upon it the boiling water, cover the vessel tightly and let it stand two hours. Then strain and pass enough water through the strainer to make the infusion weigh one hundred (100) parts.

Caution.—The strength of infusions of energetic or powerful substances should be specially prescribed by the physician. Infusions should always be prepared fresh, as they soon decompose by fermentation. Apparatus: mugs of various constructions.

DECOCTIONS.

The process consists in subjecting a complex substance, composed of soluble and insoluble matter in a divided state, to the action of boiling water, for a greater or less period of time.

The general formula of the Pharmacopœia is as follows:

An ordinary decoction, the strength of which is not directed by the physician, nor specified by the Pharmacopœia, shall be prepared by the following formula:

Take of the substance, coarsely comminuted, ten parts,	10
Water, a sufficient quantity,	
To make one hundred parts,	100

Put the substance into a suitable vessel, provided with a cover, pour upon it one hundred (100) parts of cold water, cover it well and boil for fifteen minutes, then let it cool to about 45° C. (113° F.), strain the liquid and pass through the strainer enough cold water to make the product weigh one hundred (100) parts.

Caution.—The strength of decoctions of energetic or powerful substances should be specially prescribed by the physician. Decoctions are rapidly going out of use, since the high temperature employed generally decomposes the active principle contained in the crude drug.

In Decoctions and Infusions the menstruum used is always water.

Digestion consists in subjecting a complex substance, composed of soluble and insoluble matter, to the action of fluids at an elevated temperature, but still below the boiling point of the menstruum.

The menstruum used: Water, Alcohol, Ether, Chloroform and Bisulphide Carbon.

PERCOLATION.

The principal process employed in the preparation of most pharmaceutical products. The word percolation from the Latin "percolation," derivative of "percolare," meaning to strain through. Percolation is a process of filtration by displacement, and consists in subjecting a complex substance in powder form to the solvent action of successive portions of

a menstruum in such a manner, that the liquid as it traverses the powder in its descent shall become charged with the soluble portion and pass from the apparatus free from insoluble matter.

The apparatus used to hold the powder is called a percolator; the liquid poured on top of the powder, the menstruum; the liquid passing from the percolator charged with the soluble portion, the percolate. According to the directions of the Pharmacopœia the powder of vegetable matter in the percolator is submitted to maceration for a specified period of time, before percolation proper begins. This is desirable, since the soluble and active principles of vegetable matter are in a dry condition, and usually contained in cells which are more or less broken up by the process of comminution. Maceration softens and expands these cells without loss or unnecessary use of large quantity of menstruum, besides saving valuable time. When the process is properly conducted the first percolate will be nearly saturated with the soluble constituents of the drug; the successive portions becoming lighter in color until the last portion is devoid of taste, color, and odor, except the properties present in the menstruum itself.

The quantity of menstruum necessary to exhaust the drug, depends upon the nature of the drug, and the constituents desired for the product. It is thus evident that percolation requires intelligent manipulation and a thorough knowledge of Materia Medica.

LIXIVIATION.

The process of separating soluble substances from insoluble porous matter, as shown in exhausting wood ashes with water. This process formed the basis for the process of percolation.

FILTRATION.

Filtration is a process of separation. The liquid separated from the solid held in suspension, by passing through the

pores of a medium, the latter being impervious to the former. The medium is called a filter. The solid substance retained on the filter is called a precipitate. The liquid passing through the filter is called the filtrate.

The medium or filter may consist of paper, paper pulp, ground glass, asbestos, sand, charcoal, etc.

The supporter of the filter is called a funnel. The object of the process of filtration may be: 1. The precipitate. 2. The filtrate, or merely to clarify. The rapidity of filtration is accomplished by various means; as by heat, pressure, aspirators.

STRAINING.

Straining, a process of filtration, the medium for separation being flannel, muslin, and felt; in place of a funnel, a tenaculum is used.

CLARIFICATION.

Clarification is a process of mechanical separation of solids from a liquid which impair the transparency of the liquid. Clarification may be effected in several ways.

1. By the application of Heat.
2. By the use of Albumen.
3. By the use of Gelatin.
4. By the use of Milk.
5. By the use of Paper Pulp.
6. By Fermentation.

MEANS OF CLARIFICATION.

By the appication of Heat. The separation of particles causing opacity is usually prevented by the viscid character of the liquid. The application of a small amount of heat will increase the fluidity of the liquid and thereby enable the particles to separate, rising or falling according to their specific gravity, as in the preparation of clarified honey. Such particles having nearly the same specific gravity as the

fluid itself, will rise upon boiling the liquid, forming scum which is easily removed.

By the use of Albumen. It frequently happens that the clarification of a liquid takes place on heating it, containing a substance which originally is soluble, but which is rendered insoluble by heat. This is the case with most vegetable juices which contain albumen, and this on assuming the solid state envelops the solids which may be suspended in the liquid and which caused opacity, and carries them to the surface or subsides with them to the bottom. Thus, through the intervention of albumen artificially added, clarification takes place. The albumen should be thoroughly beaten with water and added to the cold liquid and then brought to boiling. The white of an egg is usually sufficient for one gallon of liquid.

By the use of Gelatin. This is a good clarifying agent when the liquid contains Tannin, forming with it an insoluble compound subsiding to the bottom after heating.

By the use of Milk. Milk is added to liquids containing free acid, whereby casein of the milk is coagulated and precipitated and carrying with it the particles producing cloudiness. It is used as a clarifying agent for sour wines and vinegars.

The use of Paper Pulp. This is a mechanical separation of the particles producing opacity; the paper acting as a filter, and filling the pores of the strainer.

Clarification by Fermentation. This depends upon the principle that the albumen present in most vegetable juices is coagulated by the alcohol generated by fermentation as in the preparation of raspberry syrup.

DECOLORIZATION AND DEODORIZATION.

These usually accompany the process of clarification and signify the process of removing color and odor. This is accomplished by animal and vegetable charcoal.

LECTURE X.

VAPORIZATION.

The term as applied in a general way signifies the act of vaporizing, or the process of converting a solid or liquid into vapors.

As applied to Pharmacy, evaporation is a term used in a double sense: 1. When designed to separate a volatile liquid from a solid with a view to the solid. 2. When designed to separate a more volatile liquid from a less volatile one.

Evaporation is resorted to for the concentration of liquids for syrups, fluid extracts, and to effect crystallization of saline bodies, and for the dessication of vegetable matter and precipitates, the preparation of scale salts.

Evaporation is influenced by certain laws.

1. The quantity of vapor formed in a given space is constant for the temperature, and if such a space is saturated, evaporation ceases, unless some circumstance occurs to remove a portion of the vapor by condensation. Thus the use of lime, chloride of calcium, sulphuric acid.

2. The rapidity of evaporation is influenced by the state of saturation of the atmosphere, thus the advantage of the air pump.

3. When a homogeneous liquid (water) has arrived at its boiling time, its temperature remains stationary until the whole of the liquid has vaporized, provided the atmospheric pressure remains the same. But, if solid matter is in solution the temperature gradually rises until the point of saturation is attained; the solid will now be deposited.

4. The boiling point of liquids is also effected by the cohesion of the liquid, the depth of the liquid heated, the nature of the vessel used. Thus, a shallow vessel of rough interior and good conducting material increases the rapidity of evaporation.

5. Pressure influences the boiling point of a liquid. Thus, water at the pressure of 760 millimeters boils at 100° C., while on top of a mountain the boiling point is much lower, as low as 85° C.

6. In evaporation below the boiling point, (temperature, pressure and other circumstances being equal), the amount of vapor formed is in direct ratio to the extent of surface exposed to the air, and not to the quantity of liquid.

7. In evaporation by boiling, (temperature, pressure, and other circumstances being equal), the amount of vapor formed is in direct proportion to the extent of surface exposed to the fire or heating agency.

MEANS OF EVAPORATION.

Evaporation may be effected by various means.

1. By the direct radiation of heat from a fire upon the bottom of an uncovered evaporating dish or pan.
2. By a water bath.
3. By a steam bath, with or without pressure.
4. In Vacuo.
5. By an air bath.
6. Sand bath.
7. Oil bath.
8. Glycerine bath.
9. Paraffin bath.
10. Saline bath.

WATER BATH.—The principle upon which the water bath is constructed is, that all matter gives out heat to surrounding matter; water therefore, when heated, communicates its heat to any substance with which it comes in contact, until

both have the same temperature. The boiling point of water is 212° F., and consequently will communicate an equivalent temperature.

Steam Bath.—This bath affords a higher temperature, proportionate to the pressure.

At 5 lbs. pressure, the temperature is 226° F.
At 7½ lbs. pressure, the temperature is 233° F.
At 10 lbs. pressure, the temperature is 240° F.

The advantage of steam bath consists in easily controlling the temperature and effecting rapid evaporation. The liquid is not long exposed to the influence of air.

In Vacuo.—Evaporation in vacuo is accomplished by an apparatus consisting of a pan, head, condenser, and a receiver, to which a pump is attached.

The liquid, if aqueous, will commence to boil at about 120° F., and evaporation will go on actively, if the temperature is kept between 120° — 140° F. according to the degree of exhaustion maintained and the state of inspissation of the extract.

Air and Sand Baths are employed when an extreme temperature is desired, but where a naked fire would not yield a regular temperature.

Oil, Glycerine and Paraffin Baths are employed when substances are to be heated at temperatures ranging between 300° — 600° C.

Saline Baths.—Solutions containing salts require a greater quantity of heat to bring them to the boiling point, than water; the temperature ranging between 112° C. and 256° C. Their use is indicated whenever it is desired to heat a substance higher than can be done by water bath, and to maintain a uniform heat. This can be easily accomplished

by replenishing the water as it evaporates. A solution containing

50 parts of chloride calcium in 100 parts of water boils at 112° C.
100 parts of chloride calcium in 100 parts of water boils at 128° C.
200 parts of chloride calcium in 100 parts of water boils at 158° C.
325 parts of chloride calcium in 100 parts of water boils at 180° C.

SPONTANEOUS EVAPORATION.

Spontaneous evaporation depends upon the diffusion of the vapors in air. Water will diffuse in air as in a vacuum of the same area.

The rapidity of spontaneous evaporation depends:

1. On the previous state of dryness of the air.
2. On the temperature of the air.
3. On the removal of the superincumbent air, as soon as diffusion has taken place.
4. On the production of currents.

LECTURE XI.

DISTILLATION.

A process of separation, that is, to separate a liquid from a less volatile liquid or solid, with a view to the volatilized liquid.

The possibility of separating substances by vaporizing them depends upon the fact, that very few substances are volatile at the same temperature. Thus, water boils and becomes rapidly converted into vapor at 212° F., alcohol at 173° F., sulphuric ether at 98° F., oil of turpentine at 300° F., and mercury at 662° F., and some substances again are altogether fixed. By applying the proper degree of heat and no more, the more volatile of the two substances may be expelled from the less volatile; and should the two vapors rise mixed, then as they are gradually cooled the less volatile would be condensed before the other, and thus afford another opportunity for separation. This separation is often not so easily accomplished as it appears, owing to the fact that substances when pure, requiring a high temperature to volatilize them, become more easily volatilized when mixed with substances more volatile than themselves. Owing to this, it is impossible to obtain by distillation, alcohol free from water. This property is at other times used to advantage, as in the distillation of plants with water; the essential oils pass over with the steam at much lower temperature than would otherwise be necessary, and are then separated from the condensed water by other processes.

Distillation differs from evaporation in the object to be gained and in the apparatus used. The process of distillation involves:

1. The volatilization of the distilled product by heat in one part of the apparatus.

2. The condensation of the distilled product in another part of the apparatus.

The greater the difference of temperature between the vapors and the condensing surface, the more rapidly is condensation effected. The apparatus consists of two parts:

1. The retort.
2. The receiver or condenser.

RETORTS AND RECEIVERS.

The most ancient form of distilling apparatus is the Alembic; this was used by experimenters for the distillation of alcohol and formic acid. The apparatus consists of a body, cucurbit or matrass, in which the material to be volatilized was placed; a head or capital into which the vapors rose, and were cooled and then trickled down to the lower part of it, from whence, by a pipe, the distilled product passed into the receiver. Whenever very volatile substances were distilled, it was customary to increase the condensing power of the apparatus by placing the receiver in cold water. This apparatus has now been superseded by the retort and receiver, or by flask attached to a Liebig's condenser.

Retort.—The retort may be described as a flask with a long neck, which has been bent to form an acute angle with the body of the flask; this is known as a plain retort. Retorts are made of glass, porcelain, earthenware, lead, iron, and platinum, according to the purpose for which they are intended. They should be of thin glass, the exit tube should be regular and drawn small, so as to fit into the receiver easily. The highest part, or the top of the retort should be directly opposite, or nearly so, the commencement of the neck or beak. The bottom of the retort should be spherical and thin, but of equal thickness throughout, and free from imperfections. The tubulated and stoppered retort offers this advantage over the plain by being more readily

filled, and at the same time offers a simple method for a continuous flow of the liquid to be distilled.

Retorts and Receivers are of various sizes and shapes; those of glass being known as plain and tubulated and stoppered.

Receiver.—The receiver may be described as an ordinary flask with a heavy rim of glass around the top of the neck. The plain receiver is a wide-necked glass vessel, the neck tapering outwards, so as to fit the exit tube of the retort. The quilled and tubulated receiver has two openings opposite to each other, the upper one similar to the mouth of a glass stoppered bottle, the lower one tapered and drawn out to a point. The quilled receiver has been displaced by the Liebig's condenser. This consists of two tubes within each other, the inner one always of glass, the diameter of the outer one is about twice the size of the inner one, and is closed at both ends. The inner tube extends beyond the outer one at both ends. The outer tube has two tube connections for the inlet of cold water, and the outlet for the same water as it becomes heated. The inner tube acts as the receiver, and is surrounded by cold water which is kept in continuous flow, condensing the vapors as they pass through the inner tube.

Adapters.—These are tapering glass tubes which are used to connect retorts with receivers.

Funnel Tubes.—These consist of the ordinary funnel with an elongated tube, and are used to fill plain retorts without soiling the neck of the retort.

Safety Tubes.—These are modified funnel-tubes, bent in the form of an S. Their use in distillation is to regulate the sudden evolution of vapors.

FRACTIONAL DISTILLATION.

A process of distillation in which the distillate is often removed, that is, the distillate is separated as often as the densities of the distillate varies.

LECTURE XII.

SUBLIMATION.

Sublimation is a process of separating a volatile solid from a less volatile solid, with a view to the volatilized solid. The process of sublimation is similar to the process of distillation. In the latter, the eliminated product is a liquid, while in the former the product is a solid. The apparatus varying somewhat in construction and generally consisting of earthenware and iron.

The temperature at which condensation is effected influences the nature of the sublimate, producing either cake or powder sublimates.

CAKE SUBLIMATE.—These are produced when the temperature of the air in the condensor is but slightly below that at which the volatile body is capable of subliming.

POWDER SUBLIMATES.—These are produced when there is a marked difference between the temperatures in the condensor and Retort.

DESTRUCTIVE OR DRY DISTILLATION.

This is a process of distillation in which organic matter is brought to red heat without the access of air, the distillate being a liquid. Acetic acid, succinic acid, oil amber, oil cade, oil birch, etc., are all products of dry distillation.

CARBONIZATION.

CARBONIZATION is a process of heating organic substances without the access of air, until the volatile products are driven off, and the residue assumes a black color like charcoal.

Carbonization accompanies the process of dry distillation.

Torrefaction is a process of heating organic substances with access of air, modifying their constituents, but not sufficiently to carbonize them—a process of roasting.

Incineration is a process of strongly heating organic substances with the access of air, until the carbon is consumed and the ash remains, which is sought.

Ignition is a process of strongly heating a substance organic or inorganic, with access of air, the residue left being sought.

Calcination is a process of strongly heating inorganic substances without fusion, with the access of air, and usually consists in removing volatile products, such as water, carbonic acid gas chemically combined with the substance.

Fusion is a process of melting or liquifying solids, either organic or inorganic, with access of air and without the aid of a solvent. For the purpose of moulding, removing water of crystallization and moulding, to decompose, to oxidize, and to remove animal tissue.

Deflagration is a process of heating an inorganic substance with another, capable of yielding oxygen producing sudden combustion, without explosion.

REDUCTION.

Reduction is a process of reducing an inorganic substance from a higher to a lower degree of combination.

Reduction may be two-fold:

1. Complete.
2. Partial.

Complete reduction when the element is obtained; partial reduction when only reduced to a lower degree of combination. Reduction may be accomplished in the dry or wet way, by heat, and chemical means.

1. Dry method by heat:

$$Au\ Cl_3 = Au + Cl_3$$
$$Ag_2\ O = Ag_2 + O$$
$$Hg\ O = Hg + O$$

2. By Heat and Chemical means.

$$2\ Fe\ O + C = Fe_2 + CO_2$$
$$Fe\ O + H_2 = Fe + H_2\ O$$

3. Chemical means without Heat.

$$2\ Fe_2\ Cl_6 + 2\ H_2\ S = 4\ Fe\ Cl_2 + 4\ HCl + S_2$$
$$2\ Hg\ Cl_2 + Sn\ Cl_2 = 2\ Hg\ Cl + Sn\ Cl_4$$
$$Hg\ Cl_2 + Sn\ Cl_2 = Hg + Sn\ Cl_4$$
$$2\ Au\ Cl_3 + 6\ Fe\ Cl_2 = Au_2 + 3\ Fe_2\ Cl_6$$

OXIDATION.

Oxidation.—A process to combine with oxygen. Accomplished in the dry and wet method.

1. Dry Method; generally by application of heat.

$Pb_2 + O_2 = 2\ Pb\ O$; $2\ Zn + O_2 = 2\ Zn\ O$;
$2\ A2\ s_2 + 3\ O_2 = 2\ As_2\ O_3$; $S + O_2 = SO_2$;
$P_2 + O_5 = P_2\ O_5$.

2. Wet Method; Nitric Acid, Bichromate of Potassa, Manganese Dioxide and Sulphuric Acid, Chlorine in the presence of water, are the most powerful oxidizing agents.

Nitric acid is used in preparing phosphoric acid, ferric chloride, sulphate and sub-sulphate, as indicated in the following reactions:

$$3\ P_4 + 20\ H\ NO_3 + 8\ H_2\ O = 12\ H_3\ PO_4 + 20\ NO.$$

$$6\ Fe\ Cl_2 + 6\ H\ Cl + 2\ H\ NO_3 = 3\ Fe_2\ Cl_6 + 4\ H_2\ O + 2\ NO.$$

$$6\ Fe\ SO_4 + 3\ H_2\ SO_4 + 2\ H\ NO_3 = 3\ Fe_2\ 3\ SO_4 + 4\ H_2\ O + 2\ NO.$$

$$12\ Fe\ SO_4 + 3\ H_2\ SO_4 + 4\ H\ NO_3 = 3\ Fe_4\ O,\ 5\ SO_4 + 5\ H_2\ O + 4\ NO.$$

Bichromate of potassium and sulphuric acid are used in the preparation of Valerianic acid. The action as an oxidizing agent being indicated as follows:

$$K_2 Cr O_4, Cr O_3 + H_2 SO_4 = K_2 SO_4 + H_2 O + 2 Cr O_3,$$
$$4 Cr O_3 = 2 Cr_2 O_3 + 3 O_2$$

Manganese dioxide and sulphuric acid used for the preparing of chlorine and iodine, etc., its action is indicated as follows:

$$2 Mn O_2 + 2 H_2 SO_4 = 2 Mn SO_4 + 2 H_2 O + O_2$$

Chlorine for bleaching purposes, indicated as follows:

$$2 Cl_2 + 2 H_2 O = 4 H Cl + O_2$$

Oxidation may also signify, converting from a lower to a higher degree of combination, as sulphurous acid into sulphuric acid · ferrous chloride into ferric chloride.

LECTURE XIII.

CRYSTALLIZATION.

A large number of chemical substances in passing from the liquid or gaseous state into the solid, assume certain determinate forms which are bounded by surfaces of mathematical outlines, and these forms and surfaces are among the most reliable characters for distinction. These forms are called crystals; the process for obtaining them, crystallization. The process of crystallization generally takes place when the bodies are in the liquid or gaseous state under certain conditions; with a few exceptions, such as wrought iron, which is crystallized by pressure; barley sugar crystallizes by the influence of heat. Crystallization is effected by the following methods: 1. By sublimation. 2. By fusion and partial cooling. 3. By deposition from a solution saturated at a high temperature and cooling. 4. By precipitation.

1st. By Sublimation.—The method to vaporize the substance, which on condensation resolves itself into minute crystals, such as benzoic acid, pyrogallic acid and iodine.

2d. By Fusion and Partial Cooling.—A process resorted to in the case of the metals, such as bismuth, antimony, etc., and sulphur. The method to fuse the substance in a vessel, and when it is cooled down, so as to partially solidify the mass, the crust is broken through and the liquid still remaining is poured off, when a net work of crystals is obtained.

3d. By Deposition from a super-saturated solution.—A process most favorable for crystallization, and the one generally adopted in the crystallization of saline substances.

4th. By Precipitation.—Crystals obtained by the mixture

of certain solutions producing precipitates in minute crystals and usually not well defined. Many circumstances affect the crystallizing power of substances. The size of the crystals obtainable from any fluid depends much on the rate of cooling and state of commotion of the liquid. The more slowly the solution cools down, and the more quietly the process of crystallization is allowed to proceed, the larger are the crystals obtained; whilst when the liquid is rapidly cooled and agitation kept up, the crystals are comparatively small and generally not well formed. It has been found that the addition of a foreign substance, such as wire threads, or piece of wood or lead suspended in the liquid facilitates the formation of crystals. Perfect crystals may also be obtained by suspending a perfect crystal of the substance to be crystallized in the liquid. The liquid remaining after the first crop of crystals is called mother liquor, and is a saturated solution of the salt and may contain another salt. By concentrating this liquid by evaporation another crop of crystals may be obtained. This process may be repeated until the liquid is deprived of saline matter. As stated before, a saturated solution of one salt may still be the solvent of another salt. This is very important, since the purification of many salts depends upon this principle, as in the crystallization of iodides and bromides from mother liquors. Substances which do not crystallize are said to be amorphous; those which crystallize in more than one form are said to be polymorphous or trimorphous. When different substances crystallize in the same form, they are said to be isomorphous. Many substances in crystallizing combine with water chemically, which is called their water of crystallization. Crystals, losing part of their water of crystallization at the ordinary temperature, are said to be efflorescent; crystals loosing water at a high temperature, forming a dry powder, are said to be exsiccated. Crystals absorbing moisture are said to be hygroscopic, and are therefore deliquescent.

All crystalline substances possess forms belonging to one of six chief systems. These systems are based upon the mutual relations of certain imaginary lines called axes, which are supposed to run through the body of the crystal, intersecting each other at its center. These six systems of crystallization may be briefly mentioned as follows:

I. The regular, or cubic system.
II. The square prismatic system.
III. The hexagonal system.
IV. The rhombic system.
V. The monoclinic system.
VI. The triclinic system.

LECTURE XIV.

PRECIPITATION.

When a substance existing in solution suddenly looses its soluble form and separates from the liquid in a minute state of division, by the addition of another solution or liquid which may contribute to it, the process is called precipitation. The separated substance is called a precipitate, the substance producing the precipitate is called the precipitant; the liquid remaining above the precipitate, the supernatant liquid.

Precipitates are classified into two divisions: 1. Simple. 2. Complex. Simple precipitate—one obtained by changing the solvent, as the precipitate obtained from alcoholic solution of resin, or camphor by the addition of water. 2. Complex precipitate—one obtained by chemical reaction, as the precipitate obtained by the action of carbonate of soda upon chloride of calcium.

The object of precipitation is to effect pulverization, purification, and the formation of new compounds, insoluble in the liquids producing it. Precipitation is effected by heat, light, and chemical means. In the process of precipitation certain precautions must be taken. 1. If the two solutions contain proper quantities of the solid for mutual decomposition, no care need be observed, but when the proportions are not known, the precipitant is to be carefully added until it ceases to produce a precipitate. In some cases it is not indifferent which of the two liquids acts as the precipitant, as in the preparation of ammoniated mercury or ferric hydrate.

The action of the precipitant is shown by the following equation: If the solution of mercuric chloride is poured

into the solution of ammonia, so that the latter is always in excess, mercuric Ammonium Chloride is formed.

$Hg\ Cl_2 + 2\ NH_4\ HO = NHg''\ H_2\ Cl + NH_4\ Cl + 2\ H_2\ O$; but, if the ammonia solution is poured into the mercuric chloride solution, $Hg\ Cl_2$ being for some time in excess, then mercuric chloride mercuric ammonium chloride is formed, as $Hg\ Cl_2\ NHg''\ H_2\ Cl$.

In the preparation of ferric hydrate, if ferric sulphate solution is added to aqua ammonia, this being in excess, ferric hydrate alone is precipitated, as follows:

$Fe_2\ 3\ SO_4 + 6\ NH_4\ HO = Fe_2\ 6\ HO + 3\ (NH_4)_2\ SO_4$; but, if aqua ammonia is added to the ferric sulphate solution, this being in excess, some oxysulphate or hydrato oxysulphate falls with the hydrate.

$Fe_2\ 3\ SO_4 + 4\ NH_4\ HO = Fe_2\ SO_4\ 4\ HO + 2\ (NH_4)_2\ SO_4$;

$Fe_2\ SO_4\ 4\ HO = Fe_2\ SO_4\ O_2 + 2\ H_2\ O$.

Ferric-hydrato sulphate = Ferric oxysulphate and water.

Precipitates totally insoluble in water are more readily subsided by the application of heat; those that are partially soluble should be allowed to subside slowly at a gentle heat, while others again should never be heated, but should subside in the cold.

When it is desirable to form precipitates quickly, shaking or stirring will accomplish the object. Precipitates are also produced by the action of sun-light.

Nature of Precipitates.—The character of precipitates is expressed by terms such as pulverulent, flocculent, gelatinous, granular, crystalline, amorphous, heavy, light, curdy, and bulky.

Magma.—This term has reference to a thick, tenacious or gelatinous precipitate left after decanting the supernatant liquid.

Heavy and Light Precipitates.—The former are produced by hot and concentrated solutions, the latter are pro-

duced by very weak solutions. Heavy precipitates are less bulky than light ones and are more readily purified from adherent liquid by water.

Collecting and Washing Precipitates.—Precipitates are separated from the supernatant liquid by one of two methods. First.—Decantation. Second.—Filtration. Both processes have been explained in preceding lectures.

Apparatus.—To perfect the operations in the process of precipitation, the following apparatus are necessary: Precipitation Jars, Bibulous Paper, Washing-bottles, Guiding Rod, Syphous, Pipetts, Funnels and Stand.

LECTURE XV.

NEUTRALIZATION.

The term neutralization is only used when the finished product has neutral reaction; that is, indifferent to test paper, and has a salty taste.

Neutralization is effected by the action of an acid on a base or conversely.

To comprehend the subject, it is necessary that the definitions of certain familiar chemical expressions be thoroughly understood.

Atoms.—The smallest particle of an element that can enter into combination and which is considered absolutely indivisible.

Molecule.—At least two atoms must combine to produce a molecule to exist in a free state.

Radical.—When a molecule is not fully saturated in all its atomicities, it can not exist in the free state, except by union with another molecule of itself. These unsaturated molecules may be transferred without decomposition from one compound to another, and are then termed Radicals.

An Acid is a compound of an electro-negative radical with hydrogen, which hydrogen it can part with in exchange for a metal or basylous radical. This hydrogen is called the "replaceable hydrogen."

In Inorganic Chemistry, acids are generally compounds of hydrogen with a halogen or a compound radical. The compound radical consisting of oxygen and a non-metal. If soluble, they will turn blue litmus, red, and have sour taste.

An Acidulous Radical is an element or unsaturated group of elements possessing electro-negative properties, and

capable of combining with hydrogen to form an acid, or with a basylous radical to form a salt.

A Basylous Radical is a metal or uusaturated group of elements possessing electro-positive properties, and capable of displacing the replaceable hydrogen of an acid to produce a salt.

In Inorganic Chemistry, bases or basylous radicals are generally metals, their oxides and hydrates. If soluble, they will turn red litmus, blue, and possess alkaline taste.

Salts are such bodies formed by the union or attraction of bases with acids, or basylous on acidulous radicals.

The process of neutralization is employed in the preparation of certain pharmaceuticals, and in the process of acidimetrie and alkalimetrie.

PREPARATION OF TEST PAPER.

Litmus is a peculiar coloring matter obtained from various species of Roccella lichens. The pigment in the plant itself is colorless, but by the action of water, air, and alkalies during a process of fermentation, produces the substance called Litmus.

Litmus paper, or test paper, is prepared by dipping slips of white, unsized, paper into an infusion of litmus, which then should be carefully dried. This paper is used to indicate acid re-actions. As a test paper for alkalies, the paper is dipped into an infusion of litmus previously reddened by an acid, care being taken to avoid all excess.

SATURATIONS FOR PRESCRIPTIONS.

These are usually neutral products and obtained by the process of neutralization. Only the carbonates and bicarbonates of potassium and sodium, carbonate of ammonium and magnesium are used as bases; as acids, citric and tartaric acids, vinegar and lemon juice.

In preparing this class of preparations, it is important to retain as much of the carbonic gas in the solution as possible, therefore the whole quantity of water or other liquid must be added at once, and must be cold. To prevent any loss of gas it is necessary to know the respective quantities of base and acid that will neutralize each other. The finished product should be indifferent to test paper. Should the blue litmus paper turn red, although the base is not yet completely neutralized, due to the action of carbonic acid gas in solution, drying of the paper is necessary, and its color will indicate the re-action. Preparations of this nature must be kept in a cool place.

Frequently prescriptions end in (*ad saturationem acidam*, *ad saturationem alkalinam*, *ad saturationem imperfectam*); meaning respectively an acid, alkaline or imperfect saturation.

NEUTRALIZATION IN THE PROCESS OF ALKALIMETRIE AND ACIDIMETRIE.

The quantity of a base or an acid is determined by noting the volume of a test solution of an acid or alkali which is necessary to convert it into a neutral salt; the point of neutralization being usually indicated by means of a litmus solution or delicate test paper.

LECTURE XVI.

GENERATION AND ABSORPTION OF GASES.

The term gas as referring to aeriform bodies is one of comparatively modern date, and is applied to any substance when in the elastic or aeriform state. The generation of gases is of frequent occurrence in pharmaceutical practice, the most important being carbonic acid gas, sulphuretted hydrogen, chlorine, ammonia gas, and hydrochloric acid gas. Some are with difficulty absorbed by water, while others very readily. It may be broadly stated that all liquid and solid substance can absorb a certain amount of matter in the gaseous state. Liquids as a rule, absorb gases to a greater extent than solids; those solids which exhibit the greatest degree of porosity and offer the largest absorbing surface being the most active. Gases which unite with water to form compounds are absorbed in the greatest quantity, and therefore more readily, as ammonia gas and hydrochloric acid gas. Gases which are with difficulty absorbed should be passed into several receivers so that gas passing through the liquid unabsorbed may not be lost, but absorbed in the following receiver, as in the generation of carbonic acid gas, sulphuretted hydrogen and chlorine. There must be sufficient water in the generator to retain in solution the salts formed.

INFLUENCE OF TEMPERATURE AND PRESSURE.

The relation between the amounts of gas absorbed at different temperature can not be expressed by a general law, but it must in each case be determined by experiments. Gases are more rapidly absorbed by cold liquids than by hot

ones, therefore the receivers should be kept cold. has been found that the volume of a gas is inversely proportional to the pressure; that is, if one volume of a gas at the pressure of one atmosphere is represented by one or unity, the same volume of gas at the pressure of two atmosphere will be represented by $\frac{1}{2}$, at the pressure of three atmosphere, by $\frac{1}{3}$, and so on. Water always absorbs the same volume of gas without regard to the density of the gas, therefore water of medium temperature and the pressure of the atmosphere absorbs an equal volume of carbonic acid gas, and four times its volume at the pressure of four atmospheres, as shown in the manufacture of soda water.

DIFFUSION OF GASES.

All gases, whatever their density, that do not act chemically upon each other, if brought into contact, will intimately mix and diffuse themselves until a perfectly uniform mixture be formed. The lighter the gas the more quickly will it diffuse. By experimenting, the following law was established, that the rates of diffusion of any two gases are inversely as the square roots of their densities.

LIQUIFACTION AND SOLIDIFICATION OF GASES.

Taking into consideration the influence exerted by temperature and pressure upon gases, there seems to be a possibility of liquifying a gas either by abstracting heat or by increasing the pressure. Many gases have been liquified by exposure to extreme cold or by submitting them to forcible compression, and by the combined influences.

SPECIFIC GRAVITY OF GASES.

The specific gravity of gases is determined at 0° C and 760 MM pressure in comparison with air. Hydrogen is the lightest gas and frequently it is referred to as a standard. In comparison with this; the specific gravity of the elementary

gases is found to be identical with the numbers representing their atomic weights, while those of the compound gases are their molecular weights divided by two.

EXPANSION OF GASES.

It is an important fact that the co-efficient of expansion is as nearly as possible the same for all gases, so that if at 0° C we have unit volumes of atmospheric air, hydrogen, oxygen, carbonic acid gas, and other gases, and if the temperature change so as to become successively 20°, 30°, 50°, 100° C, the volume of these gases will continue equal to one another at each of these temperatures. The co-efficient of expansion is .003665 or $\frac{1}{273}$ of its volume for every degree Celcius, or $\frac{1}{490}$ of its volume for every degree Fahrenheit.

Apparatus necessary for the generation of gases for pharmaceutical purposes are: generating flask, wash bottles, connecting tubes and receiver. If on conclusion of the process of generating gas, by the withdrawel of heat, or some other cause, the evolution of gas has ceased or partially subsided, while the absorption of the gas proceeds; the gas in the generating bottle has less power of expansion, and the air pressing on the surface of the absorbing liquid may force some of it into the generating bottle. To prevent this and also to guard against too high a pressure in the generating bottle, a safety tube ought to be attached to the apparatus. If the pressure of the gas within the apparatus is greater than that of the atmosphere, the liquid in the generator will be forced up this tube, if the pressure within the apparatus is less than that of the atmosphere, the liquid in the tube will be depressed below the level of the liquid in the generator and the air will enter in sufficient quantity to equalize the pressure.

LECTURE XVII.

DIALYSIS.

Diffusion of Liquids. — Liquids diffuse in the same manner as gases. If a solution having a specific gravity greater than water is introduced into a cylindrical vessel, and then water cautiously poured upon it, in such manner that the two liquids remain unmoved, the substance dissolved in the lower liquid will gradually pass into the supernatant liquid, though the vessel was left undisturbed and the temperature remained the same. This passage of dissolved substance from its original solution into pure water, is called the diffusion of liquids.

Dialysis. — When small quantities of crystalline substances exist in a solution together with a large quantity of uncrystallizable colloid bodies, their mutual separation is affected by dialysis. This process consists in introducing the mixture into a glass vessel having a bottom made of vegetable parchment. This vessel, known as the dialyzer, is floated in a large quantity of distilled water in a basin. At the expiration of several hours the whole of the crystalline bodies will have passed through the parchment, and will have become dissolved in the water in the basin, while the uncrystallizable bodies will remain in the dialyzer. The substances which have the power of passing through the parchment, known as the septum or diaphragm, are called crystalloids, because they always have the crystalline form.

Those substances remaining upon the diaphragm are called colloids, because they never crystallize and resemble gelatine. Thus we find that dialysis depends upon the principles of diffusion.

Diffusion is generally found to take place more rapidly at high than at low temperatures.

Diffusion is more particularly rapid with crystallized substances, though not exclusively, for hydrochloric acid and alcohol are among the highly diffusive bodies, although chemical action may take place with these and account for their rapid diffusion. Non-crystalline bodies diffuse slowly, which, like gelatine are capable of forming a jelly.

The unequal power of diffusion with which different substances are endowed frequently furnishes the means of separating them. The application of the process of dialysis has been resorted to in the preparation of Dialysates, in which the active crystalline matter has been separated from gummy extractive and coloring matter such as Aconite, Belladonna, Calisaya, Colchicum, Digitalis, Nux Vomica.

In the analysis of organic substances, inert matter has been removed by dialysis, thereby removing principles which most frequently interfere with the action of chemical re-agents.

Poisonous crystalloids, such as arsenious acid and strychnine, even when mixed with large proportions of colloidal substances, may be separated by dialysis.

Dialyzed iron is a colloidal preparation extensively used, and consists of Ferric Oxychloride in water.

LECTURE XVIII.

EXTEMPORANEOUS PHARMACY.

Extemporaneous pharmacy is undoubtedly the most important branch of pharmacy; being the true and final object of pharmacy. All principles and operations of the pharmaceutical art forming only a basis for the proper compounding of prescriptions. The word "extemporaneous" is a derivative from the Latin, "Ex Tempore"; signifying "called forth by the occasion," and indicates the object of this branch of pharmacy. All medicinal preparations, officinal or galenical, as considered by the U. S. Pharmacopoeia, to be kept on hand, to be dispensed alone or used in the compounding of prescriptions, are considered permanent; while those compounded by the direction of a physician, by a prescription to meet the various occasions, are considered extemporaneous. The art of compounding these is known as Extemporaneous Pharmacy.

Quite a number of officinal preparations are considered as permanent medicines, although not permanent in keeping qualities. This class of preparations should be made in quantities sufficient to supply the immediate demand and thereby insure a continuous fresh stock. The practical and close observing pharmacist can readily judge what constitutes the necessary quantity, and soon acquire a reputation for dispensing fresh drugs. To the physician, it is of the utmost importance, that the remedies prescribed are pure and fresh. He expects certain therapeutical effects of the remedies prescribed and which will confirm the diagnosis of the case. A failure to obtain these results, and being positive in his diagnosis, will prove to him conclusively that the remedies prescribed were either not pure or fresh. It should therefore

be the duty of every pharmacist to test all remedies as to purity and strength. The last Pharmacopoeia meets all these requirements; the apparatus required and the methods of operation are simple, and with practice, experience, and careful manipulation, all tests are readily made. The introduction of this system of testing requires a review of the methods employed with definitions of common terms.

Analysis treats of the decomposition of compounds by separating their constituents. Synthesis with reference to Chemistry is the opposite operation, and treats of the preparation of compounds by building them up from their elements, as the formation of water from its elements, Oxygen and Hydrogen.

Analysis and Synthesis are in reality only the two necessary parts of the same method and have reciprocal relation.

Two kinds of analysis are in use: Qualitative and Quantitative.

Qualitative analysis is the determination of the ingredients present in the substance under examination.

Quantitative analysis is the determination of the ingredients present in the substance under examination in the exact proportions. Two methods are employed in Quantitative analysis, known as the Gravimetric and the Volumetric method of analysis.

According to the Gravimetric method, the isolated constituents are weighed, either separately or in combination; usually the latter, and the components then calculated according to their molecular weights.

According to the Volumetric method, results are obtained by the use of certain test solutions, known as standard solutions, which by chemical re-action produce certain visible effects upon the substance under examination. The substance under examination is taken by weight expressed in grammes, the test solution is taken by measure expressed in cubic centimeters.

Volumetric determinations are principally based upon Neutralization, upon Oxidation and Reduction, and upon Precipitation.

The knowledge acquired through pharmacopoeial testing will prove an invaluable aid to the pharmacist in compounding many preparations coming under the head of extemporaneous pharmacy. To practice this branch of pharmacy successfully depends mainly upon the personal qualities of the pharmacist; requiring more skill, tact, and a thorough knowledge of the fundamental principles of pharmacy and chemistry. It is necessary that he knows the solubility of solids in various solvents, the behavior of liquids with each other, the action of salts upon each other, and the physical and chemical properties of medicinal agents in general. No definite rules can be followed for the proper fulfillment of this important branch, only such general facts as named hereafter may prove of service to the student. As stated in the Introductory, it is important that the pharmacist knows in what order the medicinal ingredients are taken to fill the prescription properly. Thus many prescriptions which seemingly contain incompatibles, can easily be prepared by observing the proper order of mixing.

INCOMPATIBILITY.

This is a condition produced by bringing substances together, which results in decompositions either physical or chemical.

The most dangerous form encountered is the precipitation of alkaloidal salts by the addition of alkalies or alkaline salts.

℞ Strychninae Sulph. . . . . gr. ½
Elix. Brom-Chloral . . . . . ℥ viii
Mft. Sig. Teaspoonful morning and night.

A transparent solution is formed, but after a few hours a crystalline precipitate forms which might prove very disas-

trous. The elixir, although not officinal, is frequently prescribed, contains Bromide Potassium, an alkaline salt, which would throw out the Strychnine as an insoluble Bromide. Unless explicit directions are given in regard to shaking the bottle, the patient might get all the Strychnine in the last dose.

℞

Morphinae Sulphatis, ... gr. ii
Liq. Ammon Acetatis, ... fld. ℥s s
Aq. Destill. . . . . } a a fld. ℥ ii
Syr. Simpl. . . . . }
Mft. Sig. Teaspoonful as directed.

This prescription might also cause unlooked-for results. If too much Carbonate of Ammonium has been used in neutralizing the Dilute Acetic Acid in the preparing of the Liquor Acetate of Ammonium, a precipitate of insoluble Morphine will be produced after some time. The consequences might result as in the preceding prescription. The following prescription might also prove very annoying to the pharmacist:

℞

Potass. Iodid . . ℥ i
Spir. Aeth. Nitrosi, ℥ i
Aquae . . . . ℥ i
Mft.

Unless the Spts. Nitre is free from Nitric or Acetic Acid, either an impurity in the manufacture or generated by the influence of the air; Iodine is set free, producing a colored mixture instead of a colorless one.

Spirits Nitre is very readily affected by the atmosphere as shown by the following equation:

$$2\,C_2\,H_5\,NO_2 + 3\,O_2 = 2\,H\,C_2\,H_3\,O_2 + 2\,H\,NO_3$$

For this reason Spirits Nitre should be kept in small, well filled bottles.

Incompatibility is not only produced by substances in one prescription, but may also be produced by the re-actions of

the ingredients of two prescriptions taken during the same period of time. The following prescriptions, not uncommon by any means, form a good example:

℞ For Mr. A.
Hydrag. Chlor. Mitis. gr. iv
Sacch. Lactis, . . gr. x
Mft. pulveres No. 10.
Sig. One powder three times daily.

℞ For Mr. A.
Potass. Iodid. . . . ℥ i
Aquae Destill. . . ℥ iv
Mft. Sig. Teaspoonful every three hours.

Decomposition takes place between the Calomel and Iodide of Potassium in the stomach and might produce very serious consequences. The pharmacist must at all times take note of these chemical changes and be able to calculate and formulate the result; and if necessary consult the prescriber without alarming the patient.

Unexpected decompositions frequently occur by the addition of a soured syrup, or a syrup containing free acid to a solution containing a salt combined with a weak or volatile acid

℞
Ammon. Carb. . . . ℈ ii
Syr. Scillae, . . . fld. ℥ i
Syr. Senegae, . . fld. ℥ i
Mft. Sig. Teaspoonful when needed

In this case the presence of Acetic Acid in the Syrup Squills was probably overlooked by the physician. It liberates Carbonic Acid Gas which was not desired. The action may be very slow, and consequently may produce an explosion, especially if the cork is securely fastened in the bottle. Under such circumstances it is always advisable to triturate the salt in a mortar while adding the solution containing the weak acid. The evolution of gas is facilitated

and at the same time dispelled through the air. Whenever the Carbonic Acid Gas is desired, the physician usually prescribes the acid directly, such as Citric and Tartaric Acid. The following prescription illustrates chemical incompatibility, although intended in this case:

℞ Plumbi Acet., . $\frac{\text{aa}}{}$ gr. v
Zinci Sulph. .
Aquae Destill. . fld. ℥ iv
Mft. Sig. Externally.

In a prescription of this kind both salts should be dissolved in equal parts of water and then mixed. If the water had been added directly to both salts, the precipitate formed would have been in a more crystalline state; but by diluting each, the precipitate will be in a minute state of division. Concentrated solutions are more apt to produce precipitates, and consequently in a less fine condition. Dilution prevents this to a certain extent. Fluids which decompose each other or produce such combinations which result in unsightly mixtures, the medicinal agents held in solution should be in as diluted a state as possible, so that the resulting precipitate will be in as fine a state of division as possible and which then may be incorporated by agitation. Whenever the so-called "Coagulum" is produced as illustrated by the following prescription, the same method should be adopted:

℞ Liq. Ferri Chloridi, . . . ℥ i s s
Mucilag. Gum Acaciæ, . fld. ℥ i
Aquae Destill, ... ℥ vi
Mft. Sig. As directed.

If the Iron solution be added to the mucilage, a gelatinous mass is formed which can not be made to mix with the water, but if the Iron solution and the mucilage are both diluted with equal parts of water and then mixed, the resulting Coagulum will be in such fine state of division, that by agitation it is almost completely incorporated in the mixture.

The same method is followed with solutions containing Tannic Acid, Licorice with Metallic salts or salts of the alkaloids.

℞
Plumbi Acet. gr. iii
Tt. Opii . . fld. ℥ s s
Syr. Simpl. . . . ℥ i
Aquae Destill. . ℥ vi
Mft.

The precipitate will form under all circumstances, but by dissolving the Acetate of Lead in about half the quantity of water and the Opium tincture likewise, and then mix; the precipitate will be in a fine state of division, and may be incorporated by agitation.

℞
Plumbi Acet. . gr. xii
Acid. Tannici, . . ʒ i
Aq. Destill. . . ℥ vi
Mft.

The same method should be pursued.

℞
Infus. Cinchonae, ℥ iv
Ext. Glycyrrhizæ fld. ℥ i
Mft. Sig. Tablespoonful every three hours.

The sweet principle of Licorice, Glycyrrhizin forms insoluble compounds with the alkaloids. Therefore the medicine must be well shaken before taken. The object of using the Fluid Extract is defeated.

Tinctures containing resins in solution, such as Myrrh, Guaiacum, Assafœtida, Benzoin, Castor, Tolu, Cannabis, when prescribed with solutions containing syrup and water, should be added to the syrup and finally to the water. If water alone is prescribed, then the resinous tincture is added last, and the solution should be cold. If lumps should still form, strain through a wet muslin strainer and emusify the resinous mass with Gum Acacia.

Fixed and Essential Oils, unless prescribed in very small quantities, Oleoresin, Alcoholic Extracts, Camphor, and Chloroform, must be emulsified to be held in suspension. Salts which are very soluble, such as the Iodides and Bromides of Ammonium, Sodium, and Potassium, may be added directly to the bottle.

Salts like Sulphate of Sodium, Sulphate Magnesium, Phosphate of Sodium, Boracic Acid, should be brought into solution by the application of heat. Salts such as Chlorate

of Potassium, Sulphate of Potassium, Bitartrate of Potassium, should be triturated in the mortar with cold water. These salts are far more soluble in hot than in cold solutions, and consequently would crystallize out upon cooling.

Powders such as Subnitrate Bismuth, Chalk may be thrown directly into the bottle and shaken with a thin liquid.

Powders such as Rhubarb, Tannic Acid, Glycyrrhiza must be rubbed up in a mortar with a part of the liquid medium to prevent balling.

Quinine is always dispensed suspended in the liquid unless otherwise ordered; if acid is prescribed, the acid is added gradually to the Quinine suspended in part of the liquid; if added directly to the Quinine, a tough mass is formed which requires more acid for solution than is really necessary.

℞ Extr. Hyoscyam. Aq. ℥ s s
Tinct. Valerian, . . ℥ ii
Spir. Aeth. Nitrosi, . ℥ vi
Mft.

To prepare this prescription, the pharmacist would be justified in dissolving the aqueous extract of Hyoscyamus in one drachm of water and deducting this amount from the Sweet Spirits of Nitre, since the latter is only the diluent. The following:

℞ Ext. Hyoscyam. Aq. . . ℥ i
Tinct. Digitalis, ... ℥ i
Mft.

In this case it is necessary to mix the extract and tincture in a mortar by triturating, the tincture being gradually added. The insoluble portion being left in the mortar, since the active portion of the extract goes in solution. In the following prescription:

℞ Tinct. Iodi, . . ℥ i
Aquae, . . . ℥ i
Mft.

The addition of water to the tincture precipitates the Iodine; to avoid this, the pharmacist is justified in adding a few grains of Iodide of Potassium. The following prescription:

℞ Potass. Chlor. . . . ℈ i
Acid Hydrochlor, . . ʒ ii
Aquae Destill. . . . ℥ x
Mft. Mixtura Chlori.

To prepare this prescription properly, the following method must be adopted: the chlorate of Potassium is rubbed to a fine powder in a mortar and then placed in the bottle, to which is added a mixture of two drachms of water and hydrochloric acid and well shaken, after a few minutes the balance of the water is added, producing a yellow tinted mixture containing in solution Chlorine gas. The same prescription written as follows:

℞ Potass. Chlori. . . . . ℈ i
Acid Hydrochlor. . . . . ʒ ii
Aquae, ... ℥ x
Mft.

The physician in this instance does not desire the Chlorine gas, consequently the Chlorate of Potassium is dissolved in all the water and the hydrochloric acid is added last.

Prescriptions containing Chlorate of Potassium combined with organic matter such as Tannic Acid, Sugar, etc., producing explosive compounds, must be triturated separately and then mixed with the utmost care.

Filtration need seldom be resorted to unless the object be clarification. Whenever the solvent prescribed is insufficient for the solid, the excess should be triturated as fine as possible and retained in the mixture, with directions to shake well. It is not in the province of the pharmacist to change quantities, without consulting the prescriber. Whenever a change in the order of mixing produces a difference of appearance in the mixture, then it is necessary that the pharmacist notes

the order of mixing on the prescription, so that in case of renewal the same appearance may be produced.

In preparing prescriptions, medicines prescribed in small quantities such as "drops" should be added first to the bottle, any excess being easily removed; volatile substances such as Hydrocyanic Acid, Chloroform, Chlorine Water should be added last, to avoid loss by evaporation.

Prescriptions containing Nitrate Silver, Chlorine Water, should be dispensed in dark bottles, since light decomposes them.

MIXTURES.

Mixtures, as applied to extemporaneous pharmacy, are liquid preparations, either complete solution or solids held in suspension, intended for internal use; the bottle containing more than one dose. If taken at one dose, it is considered a Draught, if taken in very small doses, drops.

Mixtures may consist of miscible liquids as Tinctures, Fluid Extracts and Syrups. Solids in solution, such as salts, solid extracts in the proper solvent.

Insoluble substances suspended in some vehicle as Chalk Mixture.

Infusions, Decoctions, Emulsions, Saturations, either by themselves or combined with other medicinal agents.

SATURATIONS.

Extemporaneous Pharmacy considers saturations a class of preparations in which only the Carbonates and Bicarbonates of the alkaline metals and subcarbonate of Magnesia are neutralized, or partially so, by Citric Acid, Tartaric Acid, Vinegar, Dilute Acetic Acid and Lemon Juice. The principal one of these is known as Neutral Mixture. The Pharmacopoeia directs that fresh Lemon Juice be neutralized with Bicarbonate of Potassium. This is accomplished with diffi-

culty, especially when intended for immediate use. Neutral Mixture may be prepared as follows:

Citric Acid 30 grains, Bicarbonate of Potassium 45 grains, each thoroughly triturated in separate mortars, then mixed with 1 ounce of water and poured into a bottle. This formula will make a preparation identical in strength with that of the Pharmacopoeia, although devoid of the agreeable flavor of lemon. In this class of preparations as much as possible of the Carbonic Acid Gas should be retained and kept in strong vials and in a cool place. The addition of Mucilage or Licorice should be avoided, since the free acid present will produce a coagulum or a precipitate.

LECTURE XIX.

EMULSIONS.

An Emulsion is a mechanical mixture of an Oil, Fat or Resin with water; the admixture being promoted and rendered more or less permanent by the presence of a gum or an equivalent substance such as Albumen or Casein. In appearance they are like milk, opaque and generally of a thick consistence.

CLASSIFICATION.

Emulsions may be divided into two classes: 1. Natural Emulsions. 2. Artificial Emulsion.

NATURAL EMULSIONS.

Natural Emulsions are those which are found in nature as milk, milky juices of plants.

ARTIFICIAL EMULSIONS.

Artificial Emulsions are those which are prepared artificially. These are prepared from two classes of substances.

Class I.—To this class belong those substances containing an oil or resinous compound combined naturally with a gum or albuminous substance acting as the emulsifying agent, such as Seeds and Gum Resin.

Class II.—To this class belong those substances containing or consisting of an oil, either fixed or essential, Balsam, Oleo Resin, Resin, Camphor, Phosphorus, Spermaceti, Wax and Chloroform without any substance acting as emulsifying agent.

Class I.

Seed Emulsion.—These are prepared from seeds and kernels such as Almonds, Poppy, Hemp, Castor and Lycopodium. All of these contain a certain amount of fixed oils and a gummy or albuminous substance, which by the addition of water, forms the emulsion.

Preparation of Seed Emulsion: the seeds or kernels are reduced to an impalpable pulp, water is gradually added under constant trituration, thereby thoroughly incorporating the oil with the water by the aid of the natural emulsifying agent; and finally removing the pulp by straining and expression.

Emulsions of Lycopodium are not strained.

Preparation of Gum-Resin Emulsion: selected pieces of gum-resin are reduced to a fine powder and tritutrated in a mortar with small quantities of water until a uniform smooth paste is produced, and then the remainder of the water is gradually added and then allowed to settle for a few minutes. The supernatant milky mixture is then poured off and ready for delivery to the patient.

Emulsion of Ammoniacum; Myrrh and Asafoetida belong to this class. Precautions: powdered Gum-Resin should not be used, since they deteriorate in the process of grinding, bruising and sifting.

Seed Emulsions must not be heated or mixed with hot liquids and concentrated acids, since the vegetable albumen would coagulate and destroy the emulsifying agent.

Class II.

Emulsions of this class require the addition of an artificial gum or equivalent substance; the permanency of the emulsion depending on the quantity of gum or its equivalent.

Success depends largely on forming the nucleus, and special care should be exercised in determining the quantity of gum

and water necessary to emulsify the prescribed quantity of oil, fat or resin. The proportion for forming the nucleus of an emulsion of a fixed oil, balsam, or oleo resin, may be expressed as follows: oil, 1; gum, ½; water, ¾; emulsification taking place rapidly. An addition of water to this nucleus will not produce any separation. Emulsions of essential oils require a larger amount of gum; the proportions may be expressed as follows: oil, 1; gum, 1 to 1½; water, 1 to 1½; these are also quickly made, and are permanent and palatable.

Emulsifying Agents: the artificial means employed are Acacia, Mucilage of Acacia, yolk of egg, and Casein.

Process of Emulsification: place the Acacia or the emulsifying agent in a dry mortar, and add the oil gradually, triturating continuously to a uniform smooth paste. Then add the proper proportion of water at one time, triturate continuously in one direction until the oil is emulsified. This is accomplished in a very short time if the proper amount of gum and water, to the amount of oil, are used. Complete emulsification is indicated by the crackling sound while triturating. Finally, add enough water to bring the product to the proper consistency.

Precautions. I. Never use an oily graduate for the final addition of water, since the few globules of oil still remaining in the graduate when added to the completed emulsion have a tendency to bring the globules of oil together, inducing the oil of the emulsion proper to combine and thereby breaking the emulsion.

II. Heat should be avoided, although in very cold weather a warm mortar and luke warm water will facilitate emulsification.

III. Solid Extracts, Salts, Alcohol, and concentrated acids should be added in a dilute state to avoid any decomposing action on the emulsifying agent.

The following prescriptions will clearly demonstrate the method and quantities necessary to obtain a perfect emulsion.

FIXED OIL.

℞ Ol. Ricini, . . fld. ℥ i
Syr. Simpl. . . fld. ℥ i
Aquae q. s. ut ft . ℥ iii
Mft. Emulsio.

℞ Ol. Ricini, . . fld. ℥ i
Gum Acaciae, . ℥ s s
Aquae, . . . fld. ʒ vi
Mft. Emulsio.
Adde
Syr. Simplicis, . fld. ℥ i

NATURAL OLEO-RESIN.

℞ Bals. Copaibae, . fld. ℥ i
Spts. Aeth. Nitrosi, fld. ℥ i
Pulv. Cubebae, . . ℥ i
Aquae q. s. ut ft. ℥ viii
Mft. Emulsio.

℞ Bals. Copaibae, fld. ℥ i
Gum Acaciae, . . ℥ s s
Aquae, . . . fld. ʒ vi
Mft. Emulsio.
Adde
Pulv. Cubebae, . . ℥ i
Aquae, . . . fld. ℥ iv
Spts. Nitr. Aeth. fld. ℥ i

OLEO-RESIN.

℞ Oleo-resinae Aspidii, . . . ℥ ii
Ext. rad. Pumicis granat. Alcoholic, ℥ iv
Alcohol. dil. . . . . ℥ ii
Succi Liquiritiae, ... ʒ vi
Ttr. Aromat. . . . . ʒ vi
Tt. Zingiberis, ... ʒ vi
Sacch. Alb, ... ℥ ii
Mft. Emulsio.

In this case the emulsion of the oleo-resin is prepared in the usual manner and added gradually under constant trituration to the finished product of the other ingredients.

BALSAM.

℞ Bals. Peruviani, . . ℥ i
Aquae Rosae, . . ℥ iv
Mft. Emulsio.

℞ Bals. Peruviani, . . ℥ i
Acaciae, ... ℥ s s
Aquae Rosae, . . . ʒ vi
Mft. Emulsio.
Adde
Aq. Rosae, . . . ℥ iii

RESIN.

℞	Resinae Guaiaci, . ʒ ii	℞	Resinae Guaiaci, . ʒ ii
	Syr. Auranti, . . ℥ i		Gum Acaciae, . . ʒ i
Mft.	Emulsio.		Syr. Auranti, . . ʒ ii
		Mft.	Emulsio.
			Adde
			Syrupi Auranti, . ʒ vi

ESSENTIAL OILS.

℞	Ol. Terebinthinae, . ʒ i	℞	Ol. Terebinthinae, ʒ i
	Tinct. Opii, . . gtt. xx		Gum Acaciae, . . ℥ ii
	Aquae Menth. pip. . ℥ i		Aquae Menth. pip. ℥ ii
Mft.	Emulsio.	M	mulsio.
			Adde
			Aquae Menthae pip. ʒ v
			Tinct. Opii, . . gtt. xx

EMULSION OF CAMPHOR.

Camphor Emulsions are best prepared by triturating camphor to a fine powder with the aid of Alcohol, then adding Gum Acacia in the proportion of 10 to 1, and mixing thoroughly; to this mixture are added the same quantity of water as gum, and triturated in one direction until the camphor is emulsified.

EMULSION OF CAMPHOR AND OIL.

Dissolve the Camphor in Oil and emulsify in the usual way.

EMULSION OF PHOSPHORUS.

Dissolve the Phosphorus in oil, generally Sweet Almond Oil, in the proportion of 1 Phosphorus to 100 of oil, and emulsify as an oil emulsion.

EMULSION OF WAX, CACAOBUTTER AND SPERMACETI.

The respective substances are melted and emulsified according to general formula, in a hot mortar or on a hot water bath.

EMULSION OF CHLOROFORM.

Chloroform Emulsions are best prepared according to the following formula:

℞ Chloroform, . ℥ i
Gum Arabic, . ℥ ii
Water, . . . ℥ vi
Mft. Emulsio.

The resulting emulsion is more permanent and will admit of an almost indefinite addition of water. If more gum is prescribed than is necessary for emulsification, the residue may either be dissolved in the balance of water or left out altogether.

LECTURE XX.

PILULAE—PILLS.

A pill is considered a medicine in the form of a little ball or small round mass intended for internal administration. Mercantile competition caused the introduction of pills of various shapes and sizes, and under numerous titles, such as ovoid, convex and compressed.

Pill masses are officinal in the U. S. Pharmacopoeia under the title of "Massa." Pills are prescribed to a greater extent than any other form of medicine, since this form is well adapted for substances that are nauseous, bitter or unpleasant to the taste or smell, or insoluble in water, and which need not be given in large doses. Deliquescent substances should not be made into pills; efflorescent substances should be deprived of their water of crystallization. Pill masses must be of such consistence, that they shall be sufficiently plastic to admit of moulding and sufficiently firm to retain their globular form.

Pill masses consist of two parts: 1. The active ingredients. 2. The excipient, or substance used to form the mass of proper consistence. The selection of proper excipient requires a thorough knowledge of the physical and chemical properties of the substances entering into the composition of the pill mass. The pill mass should be *adhesive*, *firm* and *plastic*.

Adhesiveness is usually developed by the addition of a very small quantity of water, when that property is inherent in the particles of the substance prescribed. When this property is wanting, substances must be added which possess and can impart adhesiveness. Thus, Gum Acacia in itself when dry, does not possess this property, but the addition

of a small quantity of water develops it. Likewise, Resin becomes adhesive on the addition of a small quantity of alcohol. Solid extracts may be made soft and adhesive by heat, that is, some of the particles become semi-fluid and impart adhesiveness to those ingredients wanting in the property.

Firmness. This property is necessary so that the pill when formed, shall retain its shape. This condition may be destroyed in developing adhesiveness by adding too much liquid. It is therefore necessary to exercise a certain amount of judgment in adding the liquid or other excipient to produce adhesiveness. The evaporation of excess or the addition of dry vegetable powder will generally remedy the defect.

Plasticity. This condition results when the proper degree of adhesiveness and firmness are attained. This property may be increased by thorough kneading of the mass.

The selection of the excipient is usually left to the pharmacist, and in this selection he must also bear in mind that besides meeting the requirements of a good pill mass, it is necessary to consider the therapeutical effects of the excipient and the resulting solubility of the pill in the stomach.

Excipients. Substances which are very soft or liquid are incorporated with inert powders, such as Licorice Root, Starch, Gum Arabic, or Crumb of Bread.

Powders must be mixed with soft substances, such as Syrup, Honey, Glycerine, Confections, Soap, Mucilage, Glucose, Glycerite of Starch.

Heavy metallic substances are usually mixed with inert powders such as Licorice or Althaea Root.

Confection of Rose and Glucose are among the best excipients, when the pills are to be kept long. Glycerine also forms a good excipient for the same purpose. Dilute Hydrochloric Acid or Tartaric Acid are frequently employed as excipients to form very small pills, but these dry very rapidly and become very hard. The implements necessary, are the

mortar and pestle, Spatulas, Pill Machine, Cutters, Rollers, Pill-tile, and Finishers. The manner of kneading the mass, rolling, dividing and finishing the pill can only be acquired by practice.

TROCHISCI—TROCHES.

Troches or lozenges are small dry solid masses, of a flattened shape and consisting of powders, pleasant to the taste, incorporated with sugar and mucilage of Tragacanth. The formation of the mass is similar to that of the pill mass and must meet the same requirements, adhesiveness, firmness and plasticity. Plasticity and adhesiveness to permit flattening of the mass without crumbling; firmness to retain the shape of the formed lozenge. The excipient, Mucilage of Tragacanth, is best adapted for the formation of a Troche mass, since the moisture contained in it avoids the least delay in drying the troche and at the same time imparts the most adhesive property.

CONFECTIONES—CONFECTIONS.

Confections are preparations having the form of a soft solid, in which one or more medicinal substances are incorporated with saccharine matter, with a view to their preservation or more convenient administration.

The few confections retained by the present pharmacopoeia are intended as convenient and pleasant vehicles of other unpleasant medicines.

PULVERES—POWDERS.

A convenient form of substances, which are not given in large doses; are not disagreeable to the taste; do not possess corrosive properties, and do not deliquesce rapidly on exposure. Certain precautions should be taken in preserving this form of medicines, since it is an established fact that the effect of pulverization is the exposure of a more extended surface to

the action of the air; therefore such substances should be kept in well stoppered bottles.

Others again are affected by the influence of light, especially when in a fine state of division, and consequently should be kept in dark bottles.

It has been asserted, by good authority, that it is not advisable to keep powders as understood by the Pharmacopoeia in well stoppered bottles. Since all substances of vegetable nature require, before pulverization, a certain amount of dessication, and however carefully this process of drying is performed, most of them attract a certain amount of moisture, corresponding to an equal amount in the atmosphere. If such drugs are enclosed in air-tight vessels, they are exposed to the injurious influence of this absorbed moisture; evaporating in hot, condensing in cold weather, and producing a kind of fermentation and the growth of fungus (mould). Under these circumstances, it is considered to keep such powders in gray or blue paper bags, thereby excluding light, while the air may circulate through the pores of the paper, decreasing the liability of fermentation and formation of mould. This may produce a hardening and caking of the powder, which may upon its use be again re-pulverized.

There are two kinds of powders: 1st. Simple powders, consisting of a single substance. 2nd. Compound powders, consisting of two or more single substances.

The Pharmacopoeia considers only the latter under the head of Powders.

In the preparation of these, substances of different degree of solidity should be powdered separately, and in powdering each, it is essential that not all of the drug be employed at once, but only a part at a time, separating the coarser from the finer, and subjecting the coarser to a second pulverization; since the finer particles interfere with the coarser, adhering to the pestle and also part being dissipated through the air, producing a loss of time and material.

Deliquescent substances should not be employed since they produce moisture, which as previously stated produces fermentation, but if prescribed, as is frequently the case in Extemporaneous Pharmacy, they should be enclosed in waxed paper or other material, impervious to water.

Oily substances, whether fixed or volatile, should likewise not be used, becoming oxidized by the influence of air, producing rancidity, and imparting unpleasant odor and taste. When prescribed, should be delivered in paper impervious to water.

SUPPOSITORIA—SUPPOSITORIES.

Suppositories are solid bodies, intended to be introduced into the rectum, urethera, and vagina, with a view of producing a specific effect on the neighboring parts or on the system at large. Their form is usually conical with rounded apex, and their consistence should be such, so as to retain their shape at the ordinary temperature, but melt at the temperature of the body. The best base for suppositories is cacao butter, since it has the requisite degree of consistence and fusibility; only in the warmest weather, it is necessary to raise the melting point of cacao butter by the addition of wax, spermaceti, or suet.

Suppositories are either rolled by hand or moulded by melting and consequent cooling in moulds of various construction, or moulded by compression without previous melting. The latter process is by far preferable since the use of heat is avoided, whereby extracts containing active constituents and other alkaloidal products are usually destroyed.

EMPLASTRA—PLASTERS.

Plasters are solid compounds intended for external application, adhesive at the temperature of the human body, and requiring heat to spread them.

The basis of most plasters is Lead plaster, a compound of Olive Oil and Litharge; others again have as a basis, Resin or

Burgundy pitch. In preparing plasters, care is necessary so that the heat employed is not sufficient to destroy any volatile ingredient upon which the virtues of the preparation may depend. The finished plaster is usually shaped in cylindrical rolls, and wrapped in paper to exclude air.

Plasters should be firm at ordinary temperatures; should spread easily when heated, and after being spread should remain soft, pliable and adhesive, without melting at the heat of the human body. When long kept, they are apt to change color and become hard and brittle. This is obviated by keeping the plasters excluded from air and light in a cool place. When too hard and brittle, melting at a moderate temperature, and the addition of a small quantity of Olive Oil will remedy the defect.

The term plaster is also applied to the spread plaster, that is the solid plaster spread upon leather, linen or muslin. The implements necessary for this purpose are the plaster block, plaster iron and awl and pattern.

CERATA—CERATES.

These are unctuous substances consisting of oil or lard, mixed with wax, spermaceti or resin, to which various medicaments are frequently added. In consistence they are between the plasters and ointments, and may be spread at ordinary temperature without melting at the temperature of the human body. In preparing cerates, liquefaction should be accomplished by gentle heat, and while cooling should be stirred continually until the whole mass is solid and uniform in consistence.

UNGUENTA—OINTMENTS.

These are fatty substances, softer than cerates and of the consistence of Butter, and consequently easily applied to the skin by inunction. Most ointments are prepared by incorporating medicinal substances in a very fine state of division

with simple ointment, lard or petrolatum by thorough trituration. The medicaments added are best brought into solution or to a soft consistence by the aid of the proper solvent, before incorporating with the fatty matter. Ointments prepared by fusion should be prepared at a gentle temperature, and thoroughly stirred while cooling to insure complete mixture. Ointments prepared by chemical reaction, consists of the action of acids, especially Nitric Acid, on Olein into Elaidin, and this base combined with a metallic salt. Ointments should be free of gritty substances, and without taint of rancidity.

EXTRACTA FLUIDA—FLUID EXTRACTS.

Fluid Extracts are permanent concentrated solutions of vegetable drugs, made of such a strength that one cubic centimeter contains the medicinal principles, and represents the virtues of one gramme of the crude drug. They are prepared by the process of percolation; are permanent in keeping qualities, definite in strength, and in a concentrated form.

Fluid Extracts may be divided into two classes:

First Class. Fluid Extracts for the preparation of which Glycerine and more or less diluted Alcohol is used.

Second Class. Fluid Extracts for the preparation of which Alcohol of various strengths is used.

General Directions for Preparing Fluid Extracts: One hundred grammes of the crude drug, of various degrees of fineness, are to be moistened with a specified quantity of the menstruum, and properly packed in a percolator. The surface of the powder is then to be covered with a disk of paper, and the remaining portion of the hundred cubic centimeter of the menstruum poured upon. When the liquid begins to drop, the lower orifice of the percolator is closed with a cork, and having covered the percolator to prevent evaporation, set aside in a moderate warm place for forty-eight hours. The cork is then removed, more menstruum gradually added,

percolation continued until 70–95 C. C. have been obtained, which are reserved, the next 30–5 C. C. are evaporated carefully at a temperature not exceeding 212° F. to soft extract, and dissolved in the reserved portion, and enough menstruum added to make one hundred cubic centimeter.

OLEORESINAE—OLEORESINS.

This class of preparations were formerly considered with fluid extracts, but they differ from them in their non-uniformity of strength and in the menstruum used.

Oleoresins are liquid preparations consisting of an oil, either fixed or volatile, holding resin and sometimes other active matter in solution. They are prepared by percolation; the menstruum used being stronger ether.

EXTRACTA—EXTRACTS.

Extracts are solid preparations, obtained by evaporating concentrated solutions of vegetable drugs. The medicinal principles of the crude drug are obtained by percolation, the menstruum being either water, alcohol, alcohol of various strengths, ether, diluted acids and alkalie. Others are obtained by the expression of juices of fresh plants.

Extracts are variable in strength, since there is no definite standard for the amount of moisture to be retained in the finished product. The term of "pilular consistence" is very indefinite, and furthermore if a definite standard for pilular consistence were adopted, the finished extract would lose or gain moisture under various conditions of the atmosphere, increasing and decreasing respectively the strength of the Extract.

RESINAE—RESINS.

Resins are solid preparations consisting principally of the resinous principles of organic matter insoluble in water.

They are prepared by extracting the resinous principles with alcohol and precipitating them with water.

Resins are obtained by distillation, by percolation distillation and precipitation, or by digestion and precipitation.

ABSTRACTA—ABSTRACTS.

Abstracts; this, a new class of preparations introduced for the first time in the Pharmacopœia of 1880. Powdered Extracts had long been in existence, but were of a very unstaple and unsatisfactory condition. The loss of strength produced during the process of dessication, and the proneness to absorb moisture from the atmosphere forming hard and solid masses, made these preparations very objectionable. Likewise, the so-called solid extracts were found wanting, since they lost and gained moisture under various conditions of the atmosphere; forming preparations of a very unreliable nature and of very varying strengths.

These objectionable features of powders and solid extracts necessitated the introduction of the so-called abstracts; being convenient and reliable solid preparations bearing a definite relation to the crude drug, Fluid Extract and Tincture; being twice as strong as the crude drug and Fluid Extract, and about ten times as strong as the Tincture.

Abstracts are prepared by exhausting the drug, by the process of percolation with alcohol generally, evaporating to proper consistency at a temperature not exceeding 122° F., and adding sufficient quantity of sugar of milk to produce a fine and uniform powder of definite strength.

The alcohol used corresponding to the stronger alcohol of the Phar. 1870, being 91% by weight, or 94% by volume, especially for the reason that it is more volatile than a weaker alcohol as used in most of the corresponding extracts and fluid extracts.

TINCTURAE—TINCTURES.

Tinctures are alcoholic solutions of medicinal substances prepared by percolation, maceration, or simple solution. Several unofficinal solutions in spirits of ammonia and in

ethereal spirit belong to the same class of preparations, and are designated by the titles of ammoniated and ethereal tinctures.

Menstrua. The officinal tinctures are prepared with alcohol, dilute alcohol of various strengths, alcohol water and glycerine mixture, and aromatic spirits of ammonia.

Alcohol has been found to be the best solvent of the active constituents of vegetable matter, and at the same time miscible with almost every other solvent entering in the preparations of Pharmacopoeia. It is further desirable on account of its preservative properties. Glycerine is also used as a preservative, and to prevent precipitation to a certain extent.

Tinctures by Percolation. This process is adopted whenever the substances entering into the composition are capable of being easily comminuted and displaced.

Tinctures by Maceration. This process is adopted whenever the substances are of a resinous, balsamic, or gummy nature.

Tinctures by Solution. This process is a mere solution of inorganic substance in alcohol.

VINA MEDICATA—MEDICATED WINES.

Medicated Wines are solutions of medicinal substances, organic and inorganic, in wine. They differ from tinctures only in the nature of the menstruum; the basis being stronger white wine. This class of preparations are made as tinctures by the process of simple solution, maceration and percolation.

SPIRITUS—SPIRITS.

This class are also alcoholic solutions of volatile substances, either solid liquid or gaseous. Their preparation is accomplished by the processes of simple solution, chemical reaction, maceration, distillation, and by absorption.

ELIXIRIA—ELIXIRS.

These are sweet, aromatic, and spirituous preparations. Only one is officinal, and this is used as a diluent.

ACETA—VINEGARS.

Medicated Vinegars are solutions of medicinal organic substances in vinegar, or acetic acid. The officinal vinegars are prepared by the process of percolation with dilute acetic acid. This menstruum has been adopted since it is always of a uniform strength, while vinegar always varies in its percentage of acetic acid.

LINIMENTA—LINIMENTS.

These are preparations intended for external use, and usually applied with friction of the hand. The basis consists either of cotton seed oil, alcohol, or turpentine. They are prepared by simple solution and digestion.

OLEATA—OLEATES.

These are also intended for external use, and applied to the skin by inunction. Oleates are solutions of metallic salts or alkaloids in Oleic acid. They are prepared by incorporating the medicating ingredients by trituration. The freshly precipitated hydrato-oxides are more soluble in Oleic acid, and less liable to precipitate in the course of time than the dry oxides.

COLLODIA—COLLODIONS.

Collodions are intended for external use and are applied by a brush, forming a film which acts as a protection or brings the medicament in direct contact with the skin. They are liquid preparations consisting of pyroxylin or gun cotton in solution with alcohol and ether, combined with the medicinal agent. They are prepared by the process of simple solution and percolation.

AQUAE—MEDICATED WATERS.

A class of preparations consisting of water holding gaseous or volatile substances in solution. The substances entering into solution are either gaseous, liquid or solid. The officinal waters are prepared by simple solution, by absorption, by percolation through cotton, impregnated with the substance and by distillation. The process of filtration with magnesium carbonate has been discarded.

SYRUPI—SYRUPS.

Syrups are concentrated solutions of sugar in watery fluids, either with or without medicinal impregnation.

Varieties: 1. Syrup or simple syrup; 2. Medicated syrup.

Syrup or simple syrup is a solution of sugar in pure water.

Medicated Syrup is a solution of sugar in water charged with one or more medicinal agents.

Sugar. The U. S. Pharmacopoeia simply directs sugar but indicates by the term a sugar which is purified or refined. The proportion of sugar to liquid is very important, since the permanency of the syrup depends upon it.

Preparation. Syrups may be made either by cold or hot process, depending in many instances on the physical properties of the ingredients.

Medicated syrups are usually prepared by incorporating sugar with vegetable infusions, vinegars, decoctions, expressed juices, fermented liquors, or simple aqueous solutions.

This is accomplished by solution with or without heat, digestion, maceration, simple addition and percolation.

MELLITA—HONEYS.

Honeys are preparations resembling syrups, differing from them in the basis. The medicinal substances being incorporated with honey instead of sugar.

MUCILAGINES—MUCILAGES.

Mucilages are aqueous solutions of gum or mucilaginous principles of vegetable matter. They are prepared with or without heat, depending on the physical properties of the substances. The officinal ones are prepared by maceration and consequent straining, forming thick, viscid and adhesive liquids.

GLYCERITA—GLYCERITES.

Glycerites are solutions of medicinal substances in glycerine prepared by trituration and by heat.

LIQUORES—SOLUTIONS.

This class of preparations includes all aqueous solutions without sugar, and in which the substances acted upon are wholly soluble in water, excluding all those in which the soluble matter is gaseous or very volatile. The substances acted upon are, with the exception of two, of inorganic origin. Solution of Gutta-Percha is the only one in which the solvent water is not used. These solutions constitute the most important class of preparations of the pharmacopoeia, requiring a thorough knowledge of chemistry and the greatest care in their preparation. Their strength is such, that the relative quantity of the solid to the solvent is always in round numbers, and usually in the proportion of hundreths. Their preparation is either by simple or chemical solution.

VOLUMETRIC SOLUTIONS.

Chemical tests and examinations are one of the requirements of the present pharmacopoeia. The use of re-agents and test-solutions requires a thorough knowledge of the nature of these and of their deportment with other compounds. These examinations have been much simplified by the volumetric method of chemical examination. This method is based upon the fact that chemical substances combine in definite

and equivalent proportions. The process consists in noting the volume of a test solution of known strength required to produce, by chemical reaction, a certain visible effect when added to a known quantity of the substance to be examined. When the effect is produced, the quantity of the test solution is ascertained, the quantity of the substance examined is known, then by simple equation and calculation the result is obtained. These volumetric determinations are principally based upon neutralization, oxidation and reduction, and upon precipitation.

PROCESS BY NEUTRALIZATION.

The quantity of a base or an acid is determined by noting the volume of the test solution of an acid or alkalie which is necessary to convert it into a neutral salt, the point of neutralization being usually indicated by means of a litmus solution or delicate paper.

PROCESS BY OXIDATION AND REDUCTION.

The quantity of the substance to be determined is found by noting the volume of the test solution of the oxidizing or reducing agent to which it is equivalent, or which is required to produce a certain reaction.

PROCESS BY PRECIPITATION.

The quantity of the substance to be determined is found by noting the volume of the test solution required to cause its complete precipitation, or until a precipitate begins to form or make its appearance.

QUANTITIES.

The quantities of the substances to be examined are taken by weight expressed in grammes; the test solutions are taken by measure expressed in cubic centimeters.

VARIETIES OF SOLUTIONS.

These test solutions are known as normal, decinormal and centinormal.

Normal Solutions are such as to contain, for univalent substances, the molecular weight expressed in grammes dissolved in one liter of distilled water; for bivalent substances or salts containing two atoms of a univalent base, one-half the molecular weight expressed in grammes dissolved in one liter of pure water; trivalent substances or containing three atoms of a univalent base, one-third the molecular weight expressed in grammes dissolved in one liter of distilled water.

Decinormal Solutions are one-tenth of the strength of normal solutions.

Centinormal Solutions are one-hundreth of the strength. Certain test solutions used for technical purposes, and designed for one single object are frequently known as normal solutions. These solutions usually neutralize a certain quantity of one definite substance, or produce a certain reaction without any definite relation to the molecular weight. It is to be regretted that no definite term has been applied to the latter two solutions, as the term normal should be only applied to the former mentioned solutions.

The operations and processes employed are so varying, that no definite formula can be given to aid the student. Careful consideration and observation of the deportment, properties and relations of the re-agents with the compounds under examination are essential to successful results.